Marine Fisheries REVIEW

February 1980

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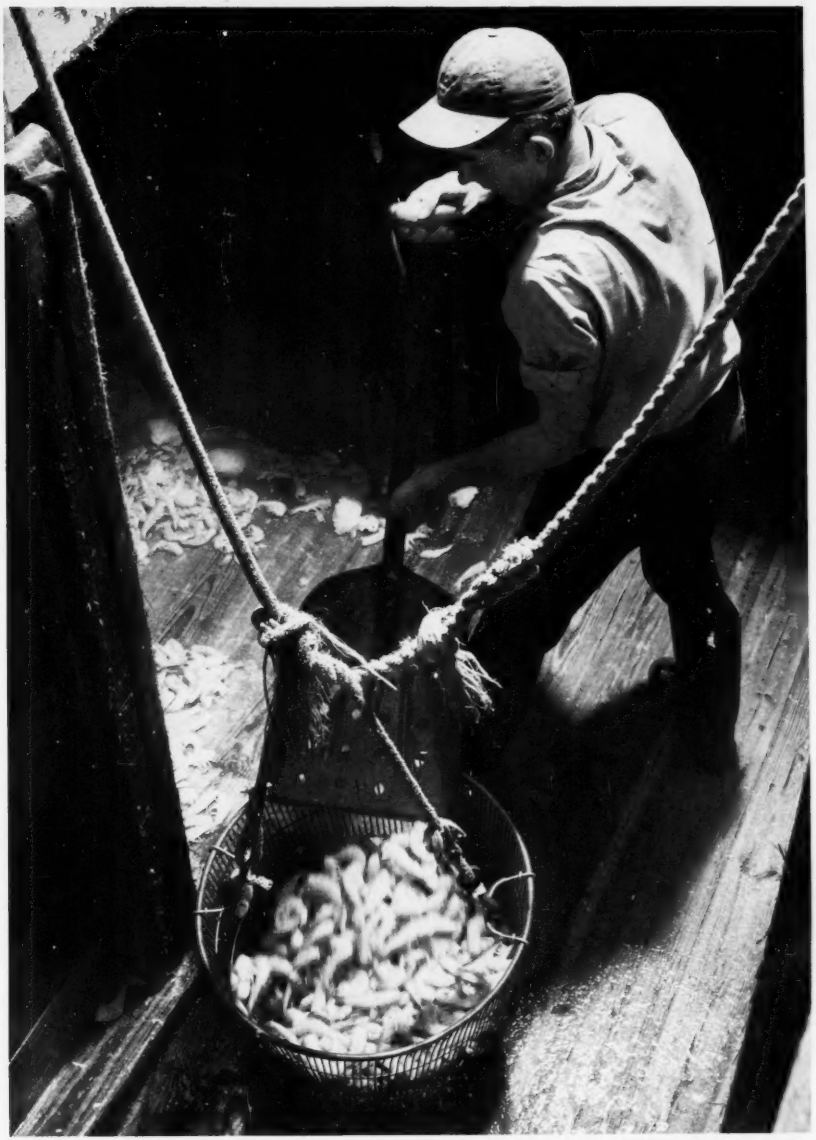

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Harvesting Gulf shrimp. Photo courtesy of the Marine Research Laboratory, Florida Department of Natural Resources, St. Petersburg, Fla.

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Costs and Returns Trends in the Gulf of Mexico Shrimp Industry, 1971-78

JOHN P. WARREN and WADE L. GRIFFIN

The Gulf of Mexico Shrimp Industry

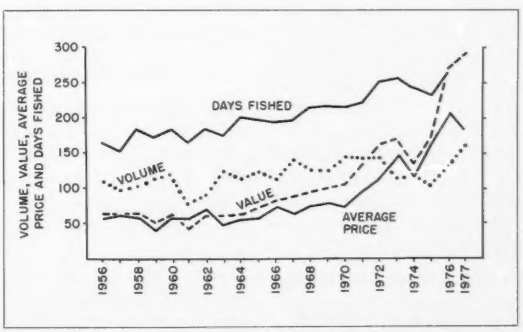
The Gulf of Mexico constitutes the most important fishing ground for United States fishermen in terms of value of catch, and shrimp fishing is the most important component of the Gulf fishery. For example, in 1977 U.S. fishermen landed over 5.1 billion pounds valued at $1,515 million, including 460 million pounds of shrimp heads on valued at $353.3 million. Of the latter figure, Gulf fishermen landed 276 million pounds (60.7 percent of the total U.S. shrimp catch in 1977) valued at $296.4 million (83.9 percent of the value of the total U.S. shrimp catch in 1977).

Total volume heads off and value of shrimp landings and average shrimp price for the Gulf of Mexico since 1956 are presented in Figure 1. These data include shrimp caught in both U.S. and Mexican waters. Mexico has instituted a 200-mile extended jurisdiction, and U.S. vessels are being phased out of Mexican waters by 1980. However, the effect of this on future landings by U.S. fishermen in the Gulf may not be severe, since recent research has determined that since 1956, U.S. landings from Mexican waters have been declining, while landings from U.S. waters have been in a general upward trend (Griffin, 1977). Specifically, annual U.S. landings from Mexican waters averaged about 22 million pounds from 1956 through 1960, but less than 10 million pounds from 1970 through 1975. Also, the proportion of U.S. Gulf landings coming from Mexican waters has never been high, and has represented only 6 or 7 percent in recent years.

As can be noted in Figure 1, both value of catch and average shrimp price have been highly variable, but the trends are upward. The days fished line provides an interesting basis for interyear comparisons (a day fished is 24 hours of fishing time). In 1959, for example, about 176,000 days fished produced total landings of about 115 million pounds. In 1973, landings were about the same, but the days fished exceeded 255,000. Also, since average size and power of vessels have increased during recent years, actual pressure on the fishery is even greater than the increase in nominal fishing days would indicate (Griffin et al., 1977).

Figure 1 also indicates the long term consistency of the Gulf fishery in producing shrimp. Landings have fallen significantly below 100 million pounds only twice, in 1961 and 1962. Research results indicate that variability from year to year in volume is highly correlated with environmental conditions in the estuaries when shrimp are young, and not from overfishing (Griffin et al., 1976). This basic dependability of the resource has made it possible for the Gulf shrimp fleets to weather the economic difficulties caused by periodic fluctuations in prices and input costs.

Figure 1.—Total U.S. Gulf of Mexico shrimp landings: Volume (million pounds), value (million dollars), average price (cents/pound), and days fished (thousands), 1956-77.



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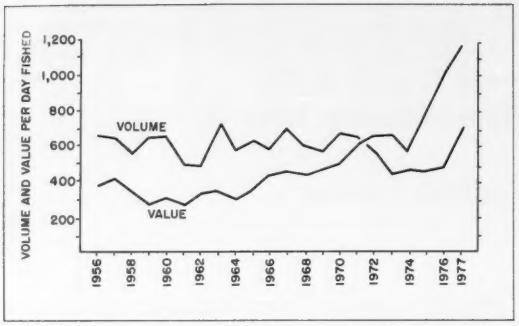

Figure 2.—Volume (pounds) and nominal value (dollars) of shrimp catch per day fished, 1956-77 (1977 values are estimated).

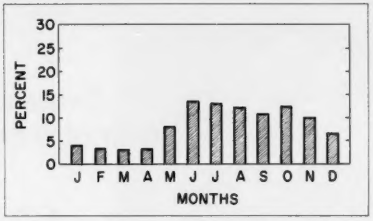

Figure 3.—Percent of annual pounds landed by months for all shrimp from all areas in the Gulf of Mexico, 1963-71. Source: Griffin et al. (1974).

Effects on fishermen of the trends represented in Figure 1 are reflected in Figure 2. The dashed line represents average value of catch per day fished, by year, for the Gulf shrimp fleet; the solid line shows average volume of catch in pounds per day fished. In spite of the increase in relative power and size of vessels, there has been little real change in average volume. However, average value shows a definite upward trend. Where the lines cross, in 1972, average price of shrimp exceeded $1 per pound for the first time.

Seasonal Variations in Catch

Seasonality is an important aspect of the Gulf shrimp fishery, particularly when investment decisions and financing arrangements are being considered. Figure 3 indicates for the Gulf as a whole the approximate seasonality of shrimp landings. From this, it is clear that the months from January to May typically do not provide particularly economical fishing conditions. Less than 15 percent of the annual catch is typically landed during the 4 months ending in April. Gulf fishermen are generally unable to turn from shrimping to other fishing activities during these periods due to the lack of a viable market for alternative species of fish or shellfish. Hence, operating losses are usually incurred during the period, with a substantial effect on profitability and clear implications for scheduling of financial obligations.

It should be noted that for those vessels that may fish primarily for pink shrimp in Florida waters, the seasonality is somewhat reversed, with peak landings in the period from December through May. Brown and white shrimp are predominant in Gulf landings, however. Hence the overall seasonality pattern is not substantially affected by pink shrimp landings.

Report Objectives

The objectives of this report are to: 1) Describe briefly the magnitude and past performance of the Gulf of Mexico shrimp industry; 2) describe recent financial performance of an "average" Gulf shrimp vessel, in terms of costs and returns and basic investment analyses; and 3) summarize data and analyses and discuss implications.

Data Description

The analyses presented in this report essentially represent a synthesis of the results of a series of economic studies of the Gulf shrimp fishery undertaken during recent years by Griffin (1977) and others (Griffin et al., 1974; Lacewell et al., 1974; Wardlaw and Griffin, 1974; Blomo and Griffin, 1978). The costs and returns financial data upon which these analyses are based were gathered through personal contact by researchers with shrimp vessel owners and/or captains operating out of ports in Florida, Mississippi, and Texas. Sample size for data collection varied from year to year. Surveys were undertaken to accumulate primary data for 1971, 1973, 1974, 1975, and 1977. Where required, costs and returns data were estimated for 1972, 1976, and 1978. Some general financial information was also obtained from officials of various lending institutions which have engaged in shrimp vessel financing. For the primary data, variable cost items were divided into: Ice; fuel; nets, supplies, and groceries; repair and maintenance; crew shares; payroll taxes and other employee-related expenses; and packing charges. Variable cost data reported by the vessel owners were used.

Fixed cost items included: Insurance, depreciation, interest, and opportunity cost. Fixed charges for insurance and overhead are reported data, while charges relating directly to investment—depreciation and interest for costs and returns budgets—were calculated in nominal dollars for new vessels. Specifically, the standard formula for straight-line depreciation is $D = (I - S)/L$, where D = yearly charge for depreciation, I = new vessel price, S = salvage value, and L = depreciable life in years.

New vessel prices were estimated from cost data collected from vessel owners. Typically, owners were asked to estimate replacement cost of their

vessels. Depreciation charges were calculated using straight line depreciation, typically with 8-year depreciable life and 35 percent salvage value.

The difference in expected terminal value and book value should be specifically recognized. As noted, book salvage value was usually taken as 35 percent of original cost, based on accounting practices in use for the fishery. However, expected terminal value is generally much higher. The reason for this difference is that even in periods of minimal new vessel price escalations, most vessel owners have been able to sell or trade their vessels at the end of their holding period for values of up to 100 percent of the original cost.

Interest charges for costs and returns budgets, and interest and principle payments for cash flow budgets were calculated using 67 percent debt financing at appropriate rates of interest; for 8 years, with 12 equally amortized payments per year. These terms were found to be representative from interviews with vessel owners.

Methods Used in Analysis of Data

All costs and returns and other financial data for vessels were handled in a standardized manner. A systematic procedure was established to assimilate and tabulate the data for the various analyses (Wardlaw and Griffin, 1974). Interest rate, percent financed, number of years financed, number of loan payments per year, depreciation method, crew share agreement, rate of packing charges, payroll tax rate, discount rate, planning horizon, and object year under consideration were standardized to represent some "average" vessel. This procedure is organized in a computer program format referred to as a budget-generator. The program reports results in the form of total costs and returns budgets, unit costs and returns budgets, and projected cash-flow budgets. Basic procedures used are as follows.

Costs and Returns Budgeting

Costs and returns budgets presented in this study are similar to annual income statements, with a subsection below each showing required return to equity capital and returns to owners' labor and management. The formula used in calculating opportunity cost (required return to equity capital) is $OC = E(R)$, where OC = annual opportunity cost, E = equity, and R = required rate of return to equity capital. Opportunity cost used in this study applies to equity capital only (vessels in the samples typically represented leveraged investments), and all returns are measured with respect to the equity capital used to gain ownership of income-generating assets. In economic and financial analysis, it is important to differentiate between required return on investment and returns to owners' labor and management.

The equity requirement for investment in vessels was assumed to be a pool of liquid assets which could have been invested elsewhere. The rate of return for this pool of equity capital should be based on the rate on the next best alternative use of this capital. However, after the investment is committed the required return to equity capital must be adjusted to take into consideration the associated loss of liquidity. In general, the more liquid an investment, the less the financial risk associated with it (Hopkin et al., 1973). In other words, since a loss of liquidity occurs after the purchase of a shrimp vessel, a financial "risk premium" must be added to the rate of return on an annual basis for the next best alternative use for the equity capital. The "risk premium" is somewhat arbitrary in that each vessel owner is in a unique situation and each has different risk-return preferences and investment alternatives. The risk premium was estimated at various levels between 1.1 and 2.0 percent for the different studies reflected in this report. Hence, required rate of return in each of the analyses drawn upon for this report is made up of a base rate, usually determined by the yield on Baa corporate bonds, plus the financial risk premium (Wardlaw and Griffin, 1974).

There are other types of risk, which reflect elements of uncertainty for the firm arising from other than purely financial considerations, such as market conditions, weather, environmental factors, etc. In this study, such business risk is assumed to exist but no attempt is made to quantify it.

Returns to owners' labor and management are simply excess returns over the fixed and variable costs. No absolute requirements were applied here, although each vessel owner must evaluate that item in terms of his own abilities.

Cash Flow Budgeting

A pro forma cash flow statement provides a means of projecting the timing and magnitude of cash inflows and outflows for the business over a given period of time (Hopkin et al., 1973). It identifies those periods that may exhibit a shortage of cash, and indicates needs for securing additional cash. The pro forma cash flow also helps identify those periods which exhibit an excess of cash above projected needs, thereby indicating opportunities for other investment (including early loan retirement) to best utilize that excess. Cash flow projections are presented for specific periods on both monthly and annual bases, and illustrate the demands on cash during a typical calendar year and over a planning horizon of 8 years.

Investment Analysis

Investigating the feasibility of any investment alternative is a very subjective undertaking. Each vessel owner must set those standards of performance for the investment which are most meaningful in terms of his own situation. However, without some set of established criteria for evaluation, no basis for decision would exist. For this study, two methods of discrimination were established: 1) Internal rate of return to original equity capital, and 2) payback period. For one analysis, net present value (NPV, or the net value in present dollars of the expected future income stream, using required rate of return as the discount rate) was applied.

Internal Rate of Return Criterion

Internal rate of return to equity capital analysis is a standard tool used to

evaluate investments, and is a measure of the time value of cash flows. The internal rate of return to equity is the discount rate necessary to set the sum of the present values of the net cash inflows per period equal to the original equity requirement (Hopkin et al., 1973). The formula used to calculate internal rate of return to equity is

$$I = \sum_{n=1}^{N} P_n(1+d)^{-n},$$

where I = initial investment (equity requirements), N = planning horizon in years, P_n = net cash inflow for a period n, d = discount rate which equates initial investment and present value of net cash inflows, or internal rate of return (IRR).

Payback Period

The payback period of an investment with respect to the equity requirement is the length of time that elapses between the intial investment and that period when the accumulated flow of undiscounted net operating returns generated by the investment equals the investment.

Results

Annual Costs and Returns

The results of annual costs and returns studies undertaken for the years 1971, 1973, 1974, 1975, and 1977 are summarized in Figure 4. A breakdown of costs and a presentation of differences in sample size, shrimp price, vessel financing, and depreciation among the five samples are presented in Table 1. In each case, the object year for figuring fixed costs is the fifth year of vessel ownership.

Profits were experienced by the average vessel in 1971, 1973, and 1977. However, substantial losses were incurred in 1974 and 1975, with 1974 a particularly bad year. A review of variable costs shows that average fuel costs (in recent years the largest single cost item except for crew shares) tripled between 1971 and 1974 and doubled between 1973 and 1974 (Table 1). The increasing input prices brought about by the energy crisis, accompanied by a decrease in average ex-vessel price received for shrimp between 1973 and 1974 and the decline in Gulf wide production in 1973, 1974, and 1975 (Fig. 1), produced a disastrous financial situation for Gulf shrimp fishermen. Those who were able to weather the situation in 1974 found conditions improving, but still uncertain in 1975. Although price of shrimp increased significantly, the industry was still faced with severe adjustments to increasing prices for the goods and services necessary to operate in the industry.

One feature of the analyses reflected in Table 1 which should be brought out is that in each case, the depreciation portion of fixed costs may be too high, resulting in underestimation of profitability. The reason for this is that whereas sample vessels were depreciated to 35 or 50 percent salvage value over 8 or 10 years, in practice, vessel owners have been able to command substantially higher prices for used vessels.

Figure 4 provides a meaningful interyear comparison of "average" Gulf vessels. However, there are also variations in average financial performance between vessels of different configuration. In Table 2 the 89 Texas and

Table 1.—Average variable and fixed costs in dollars for Gulf of Mexico shrimp vessels, 50-80 feet in length, all types of construction, 1971-77.

Item	1971	1973	1974	1975	1977
Variable costs					
Ice	1,387	1,579	1,541	1,766	2,788
Fuel	6,561	9,539	18,976	19,114	20,194
Net, supplies, groceries	2,358	6,747	9,885	11,211	13,131
Repair & maintenance	11,708	9,593	9,337	11,643	11,143
Crew shares	19,437	23,723	26,593	32,422	43,320
Payroll taxes	388	474	1,547	1,815	257
Packing	2,411	1,899	2,428	2,905	3,852
Subtotal	44,250	53,554	70,307	80,876	94,685
Fixed costs					
Insurance	3,632	4,291	4,306	4,840	5,677
Depreciation	6,333	8,177	11,228	12,607	14,623
Overhead	0	2,415	3,201	3,073	3,194
Interest	2,256	2,611	5,604	6,984	6,880
Subtotal	12,221	17,494	24,339	27,504	30,374
Total operating costs	56,371	71,048	94,646	108,380	125,059
Vessels in sample	25	103	109	101	81
Average shrimp price ($/lb.)	1.20	1.85	1.70	2.30	2.39
New cost of vessel	77,949	100,641	138,188	155,168	179,981
Percent financed	67	67	67	67	80
Depreciable life (years)	8	8	8	8	8
Salvage value (percent)	35	35	35	35	35
Required return rate[1] (percent)	10.25	9.50	13.00	14.00	15.00

[1]Reflects a base rate, determined by bond yields, plus a financial risk premium.

Sources: Blomo and Griffin (1978); Griffin (1977); Hayenga et al. (1974); and Lacewell et al. (1974).

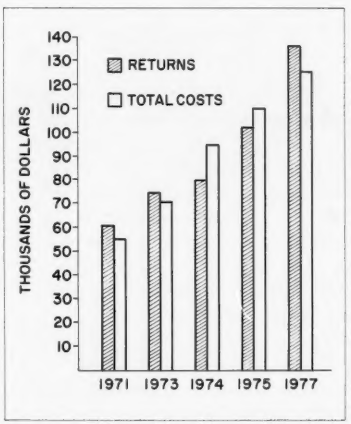

Figure 4.—Average annual costs and returns in nominal dollars for Gulf of Mexico shrimp vessels, 50-80 feet in length, all types of construction, 1971-77. Sources: Blomo and Griffin (1978); Griffin (1977); Hayenga et al. (1974); and Lacewell et al. (1974).

Table 2.—1977 average annual costs and returns for 89 Gulf of Mexico shrimp vessels in different size classes.

Item	28-35 feet	36-55 feet	56-80 feet
Receipts, shrimp sales	15,849	32,941	135,216
Variable costs			
Ice	494	1,143	2,788
Fuel	2,064	4,130	20,194
Nets, supplies, groceries	1,056	4,448	13,131
Repair & maintenance	1,407	3,312	11,143
Crew shares	11,532	11,062	43,320
Payroll expenses	843	0	257
Packing	155	1,125	3,852
Subtotal	17,551	25,220	94,685
Fixed costs			
Insurance	0	1,596	5,677
Depreciation	2,874	4,812	14,623
Overhead	145	74	3,194
Interest	1,352	2,264	6,880
Subtotal	4,371	8,746	30,374
Total operating costs	21,922	33,966	125,059
Profit or loss	−6,073	−1,025	10,157
Required return to equity	6,177	3,485	5,399
Return to owner management	−12,250	−4,510	4,758
Vessels in sample	3	5	81
Vessel value	35,377	59,228	179,981
Depreciable life (years)	8	8	8
Salvage value (percent)	35	35	35
Object year	5	5	5
Percent financed	80	80	80
Interest rate (percent)	9	9	9
Required return rate (percent)	15	15	15

Source: Data generated by Department of Agricultural Economics, Texas A&M University.

Florida vessels sampled for 1977 costs and returns information are considered in terms of hull size. Three of these vessels are between 28 and 35 feet in overall length, five are between 36 and 55 feet, and 81 are between 56 and 80 feet in length. Clearly, there are large differences in costs and returns due to size in this sample. The data reflected in Table 2 indicate that larger vessels are significantly better investments than smaller ones, based on the 1977 data.

Monthly Cash Flows

The monthly cash flow analysis for a 1971 sample of Gulf shrimp vessels is presented in Table 3. Monthly cash flow projections are important in scheduling the timing and magnitude of special expenditures and loan repayment capacity. As indicated in Table 3, the monthly flow of net returns is affected directly by the level of fishing activity; hence, positive returns are expected during peak shrimping months from June or July through December. From January to June returns above variable costs for the sample vessels are insufficient to cover the loan payment for an average vessel. Although these data reflect the performance of a small sample during one calendar year, results for data collected for the 1975 season were very similar, which indicates that this can be considered typical for the fleet. Implications for financial planning in the industry are clear.

Annual Cash Flows

In Table 4 an average annual cash flow for 81 vessels sampled for 1977 is presented. The cash flow is based on 80 percent financing for 8 years of a new 56-80 foot vessel with average cost of $179,981.

Costs and returns are assumed to continue during the period at constant 1977 levels. Since 1977 represented a respectable year in terms of profitability, this assumption results in a very favorable projected cash flow. However, initial investment is paid back and a positive cumulative cash position is achieved only in the final year of ownership. The assumption that the vessel can be sold at the end of the period at 100 percent of new cost provides a large increment to the cash position. Based on this analysis, internal rate of return is calculated a relatively high 27.79 percent.

This cash flow (Table 4) illustrates the results of an investment analysis based on a continuation of the rather favorable conditions of 1977. It is interesting to examine an annual, investment-period cash flow that considers annual variations in costs and returns. In Table 5, such an analysis is presented.

For this analysis, it is assumed that a new vessel is purchased in 1971, at average 1971 vessel cost; with 67 percent financing for 8 years and 12 equally amortized payments per year at 9 percent interest. Depreciation is straight-line over 8 years, and results are calculated using both 35 percent salvage value and 100 percent resale value in 1978. Actual results from the 1971, 1973, 1974, 1975, and 1977 vessel samples are used to estimate average costs and receipts for those years. Cost and receipt values for the missing years of 1972, 1976, and 1978 are estimated based on data from adjacent years. Results of this estimation are reasonably consistent with known conditions during those years, although overall results in the fishery in 1976 indicate that profitability for that year may be underestimated, based on an average of 1975 and 1977 costs and receipts.

The analysis shows that actual performance of an investment in a shrimp vessel is likely to be less successful than the case in Table 4 suggests. However, the actual performance with the 1971 base year still produces a positive net present value of cash flow and an acceptable internal rate of return. Of course, if the vessel can be sold at the end of the period at or near 100 percent of its original cost, the investment is very satisfactory, as shown in the final column of Table 5.

The analysis reflected in Table 5 also shows that average total cash inflow from shrimp catch doubled during the period. Likewise, total annual outflow increased by around 80 percent for an average vessel. Initial cash investment was paid back during the sixth year of vessel operation, assuming no significant cash withdrawals by ownership. Hence, payback was achieved during the operating life of the investment. However, a substantial portion of overall returns to the investment is tied to the ability to sell the vessel at the end of the period. (For example, if the average vessel in the Table 5 analysis had zero salvage value after 8 years, the net present value (1971 base) of the cash flow at a 10 percent cost of capital would have been a negative $1,240, and the internal rate of return to the investment would have been below 9 percent.)

Summary and Implications

A review of the results of the above discussion points up several key factors in the financial performance of Gulf of

Table 3.—Cash flow analysis in dollars of average returns, variable costs, and fixed payments by month for eight Gulf of Mexico shrimp vessels, 50-80 feet in length, all types of construction, 1971.

Category	Monthly summary of returns and expenses											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Production												
Pounds	2,787	2,825	2,589	2,434	3,707	4,361	7,754	8,382	6,402	6,959	5,385	4,348
Price per pound	1.08	1.10	1.20	1.28	1.35	1.07	0.95	1.14	1.25	1.39	1.47	1.54
Total receipts	3,009	3,107	3,107	3,115	3,654	4,667	7,367	9,556	8,003	9,673	7,916	6,696
Operating inputs												
Ice	78	72	107	108	99	140	261	112	114	152	139	68
Fuel	544	606	648	639	572	630	731	286	465	726	749	511
Nets	75	25	33	51	74	53	172	35	29	61	21	50
Supplies	112	64	403	262	184	122	170	97	143	235	222	71
Electricity	5	113	99	46	49	52	47	141	148	186	101	42
Repair & maintenance	979	779	1,169	1,342	814	1,266	551	878	993	929	1,223	1,021
Packing	154	136	127	59	126	151	375	451	305	487	248	264
Shares	1,053	1,087	1,087	1,090	1,279	1,633	2,578	3,345	2,801	3,386	2,772	2,344
Total	3,000	2,882	3,673	3,597	3,197	4,047	4,885	5,345	4,998	6,162	5,475	4,371
Return above variable cost	9	225	−566	−482	457	620	2,482	4,211	3,005	3,511	2,441	2,325
Accumulated returns above variable cost	9	234	−332	−814	−357	263	2,745	6,956	9,961	13,472	15,913	18,238
Fixed payments												
Insurance	308	308	308	308	308	308	308	308	308	308	308	308
Principal and interest[1]	1,062	1,062	1,062	1,062	1,062	1,062	1,062	1,062	1,062	1,062	1,062	1,062
Total	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370	1,370
Net returns	−1,361	−1,145	−1,936	−1,852	−913	−750	1,112	2,841	1,635	2,141	1,071	955
Accumulated net returns	−1,361	−2,506	−4,442	−6,294	−7,207	−7,957	−6,845	−4,004	−2,369	−228	843	1,798

[1]Interest calculated at 8 percent
Source: Hayenga et al. (1974).

Table 4.—1977 average annual cash flow statement for 81 Gulf of Mexico shrimp vessels of 56-80 feet in length, all types of construction.

Year	0	1	2	3	4	5	6	7	8
Investment[1]	179,981	0	0	0	0	0	0	0	0
Down payment	35,997	0	0	0	0	0	0	0	0
Loan balance	143,984	131,197	117,022	101,616	84,765	66,333	46,172	24,120	0
Receipts from sales	0	135,216	135,216	135,216	135,216	135,216	135,216	135,216	135,216
Capital sales	0	0	0	0	0	0	0	0	179,981
Total cash inflow	0	135,216	135,216	135,216	135,216	135,216	135,216	135,216	315,197
Cash operating expenses[2]	0	103,556	103,556	103,556	103,556	103,556	103,556	103,556	103,556
Loan payments[1]									
Principal	0	12,877	14,085	15,406	16,851	18,432	20,161	22,052	24,121
Interest	0	12,436	11,228	9,906	8,461	6,880	5,151	3,260	1,191
Income taxes[3]									
On ordinary income	0	1,012	1,277	1,568	1,886	2,234	2,614	3,030	3,486
On recaptured depreciation[4]	0	0	0	0	0	0	0	0	25,736
Capital purchases[1]	35,997	0	0	0	0	0	0	0	0
Total cash outflow	35,997	129,881	130,146	130,436	130,754	131,102	131,482	131,898	158,090
Net cash inflow	−35,997	5,335	5,070	4,780	4,462	4,114	3,734	3,318	157,107
Cumulative position	−35,997	−30,662	−25,592	−20,812	−16,350	−12,236	−8,502	−5,184	151,923
Approximate internal rate of return (percent)									28

[1]Based on new vessel cost of $179,981; 80 percent financed for 8 years; 12 equally amortized payments per year, at 9.00 percent interest rate.
[2]Exclusive of principal and interest payments.
[3]Based on income tax rate of 22 percent.
[4]Based on sales price of $179,981.
Source: Department of Agricultural Economics, Texas A&M University.

Table 5.—Estimated annual cash flow in dollars for an average 56-80 foot Gulf of Mexico shrimp vessel purchased in 1971 and operated 8 years.

	Beginning 1971	1971	1972[1]	1973	1974	1975	1976[2]	1977	1978[2]	1978[2,3]
Investment[4]	77,949	0	0	0	0	0	0	0	0	0
Down payment[4]	25,724	0	0	0	0	0	0	0	0	0
Loan balance[4]	52,225	47,415	42,192	36,522	30,366	23,683	16,427	8,549	0	0
Receipts from sales	0	60,742	67,439	74,135	78,864	101,324	118,270	135,216	118,270	118,270
Capital sales	0	0	0	0	0	0	0	0	27,282	77,949
Total cash inflow	0	60,742	67,439	74,135	78,864	101,324	118,270	135,216	145,552	196,219
Cash operating expenses[5]	0	47,882	54,071	60,260	77,814	88,789	96,172	103,556	96,172	96,172
Loan payments[4]										
Principal	0	4,810	5,223	5,670	6,156	6,683	7,256	7,878	8,549	8,549
Interest	0	4,129	3,717	3,269	2,783	2,256	1,683	1,061	386	386
Income taxes[6]										
On ordinary income	0	527	730	940	0	868	3,098	5,338	3,163	3,163
On recaptured depreciation	0	0	0	0	0	0	0	0	0	11,147
Capital purchases	25,724	0	0	0	0	0	0	0	0	0
Total cash outflow	25,724	57,348	63,741	70,139	86,753	98,596	108,209	117,833	108,270	119,417
Net cash inflow	−25,724	3,394	3,698	3,996	−7,889	2,728	10,061	17,383	37,282	76,802
Cumulative position	−25,724	−22,330	−18,632	−14,636	−22,525	−19,797	−9,736	7,647	44,929	84,449
Approximate 1971 net present value of cash flow at 10 percent required return (NPV)									11,965	29,960
Approximate internal rate of return (percent)									16	24

[1]Receipts and expenses estimated based on 1971 and 1973 average.
[2]Receipts and expenses estimated based on 1975 and 1977 average.
[3]Second 1978 column assumes vessel is sold in 1978 at 100 percent of 1971 purchase price.
[4]Financing based on 1971 average vessel price, 67 percent financed for 8 years, 12 equally amortized payments per year at 8.25 percent.
[5]Based on total costs from Table 2 (for 1971, 1973, 1974, 1975, and 1977), less depreciation and interest.
[6]Tax rate constant at 22 percent, depreciation straight-line, 8 years, 35 percent salvage value.

Mexico shrimp vessels. First, owners of these vessels are faced with highly variable cost/price relationships, which has tended to produce a "feast or famine" cycle in the industry in recent years. The fact that most vessels are tied almost entirely to only one type of fishing and one product accentuates the effects of changing prices on vessel owners. The result is a fairly high degree of short run uncertainty for producers.

A second key factor is the seasonality of production, with its implications on financing and investment. Related to seasonality is the dependence of the fishery on shrimp abundance. Although there continue to be periods of low or inconsistent abundance in the fishery, over the long term, the availability of shrimp seems to return to fairly stable levels given existing fishing pressure.

The vessel itself is a third important factor in considering financial worthiness in Gulf shrimping. Configuration, vessel financing, and resale value all have a large impact on shrimp vessel investment analysis. A related subject, which is beyond the scope of this paper but certainly of extreme importance in determining financial success for a vessel, is the quality of captain and crew.

In summary, it has been shown that profitability for Gulf shrimp vessels in recent years has been highly variable, due largely to changes in input costs; shrimp prices; landings; and the cost, financing terms, and configuration of vessels. It has also been shown that based both on the results of very good years and on the results of a number of highly varied years, ownership of a Gulf shrimp vessel can be a satisfactory investment over an extended ownership period.

Acknowledgments

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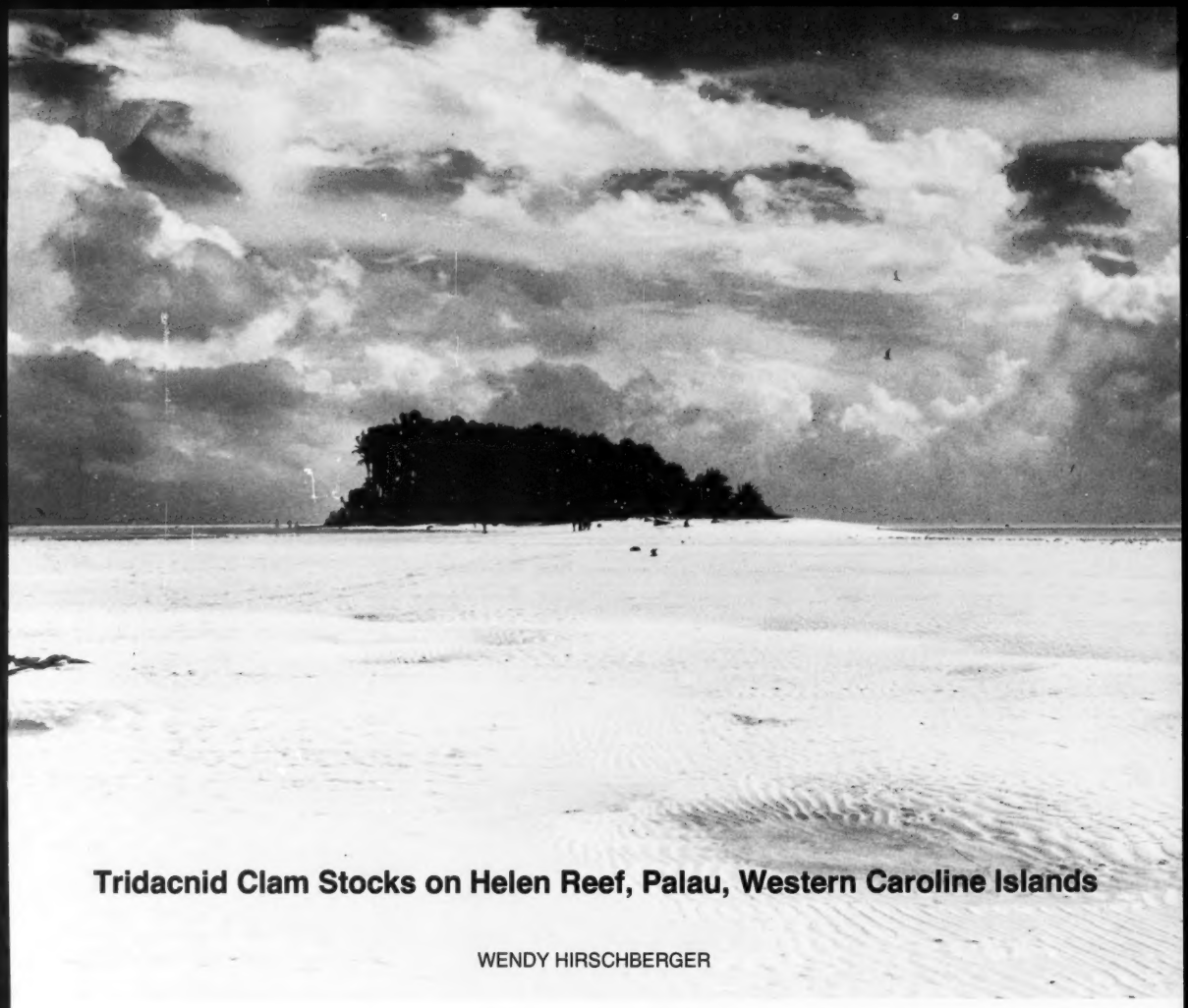

Tridacnid Clam Stocks on Helen Reef, Palau, Western Caroline Islands

WENDY HIRSCHBERGER

ABSTRACT–A survey of Palau District's Helen Reef was conducted in May 1976 to continue monitoring changes in tridacnid clam abundances. The densities of the four largest tridacnid species were slightly higher than observed in 1975; however, ratios of live individuals to empty shells continued to remain very low. Only Hippopus hippopus *showed a substantial decrease in the percentage dead. This is in contrast to* Tridacna maxima *which is subject to relatively no fishing mortality and showed less than 5 percent dead. These smaller species may possibly be used as natural population indicators at Helen Reef.* Tridacna squamosa *is still rare, probably owing to poor environmental conditions for this species.*

Introduction

Overexploitation of tridacnid clam populations appears to be a current problem in many areas of the Indo-Pacific. One area where some of the effects of harvesting have been studied is Helen Reef, a small atoll in the south Palau District, Western Caroline Islands, Trust Territory of the Pacific Islands. The submerged reef and lagoon, lying at approximately lat. 3°N and long. 131°E (Fig. 1, 2), occupy about 216 km² with a small island (Helen Island) located at the northern end. Depths inside the lagoon exceed 60 m; outside, the bottom slopes steeply. This remote area is uninhabited and receives only occasional visits from U.S. Trust Territory outer island support ships and foreign fishing vessels.

Figure 1.—Helen Island at Helen Reef atoll, in Palau's southwest islands.

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In May 1971, the NOAA research vessel *Townsend Cromwell*, operated by the National Marine Fisheries Ser-

vice, NOAA, conducted a survey of the Trust Territory's marine resources. Only a stop was made at Helen Reef at this time, and the ship returned in March 1972 to survey the tridacnid clam populations. In their report, Hester and Jones (1974) concluded that the tridacnid populations at Helen Reef were large and that *Tridacna gigas* and *T. derasa* could possibly withstand a moderate, controlled fishery.

A resurvey effort was undertaken in April 1975 by a team of biologists supported by the Palau District Marine Resources Office, a division of the Trust Territory Department of Marine Resources, in response to increasing reports of foreign fishing vessels in the Helen Reef area. They found that tridacnid clam populations had apparently been reduced since 1972 (Bryan and McConnell, 1976).

In 1976 the Palau Marine Resources Office requested another resurvey in response to continued reports of unauthorized fishing vessels in the Helen Reef area. There was concern that continued fishing in this area could lead to severe stock depletions, with small chances of recovery. This report gives a description of the 1976 resurvey effort, monitoring changes in the abundance of tridacnid clams on Helen Reef, and provides population densities of the area with comparison to earlier surveys.

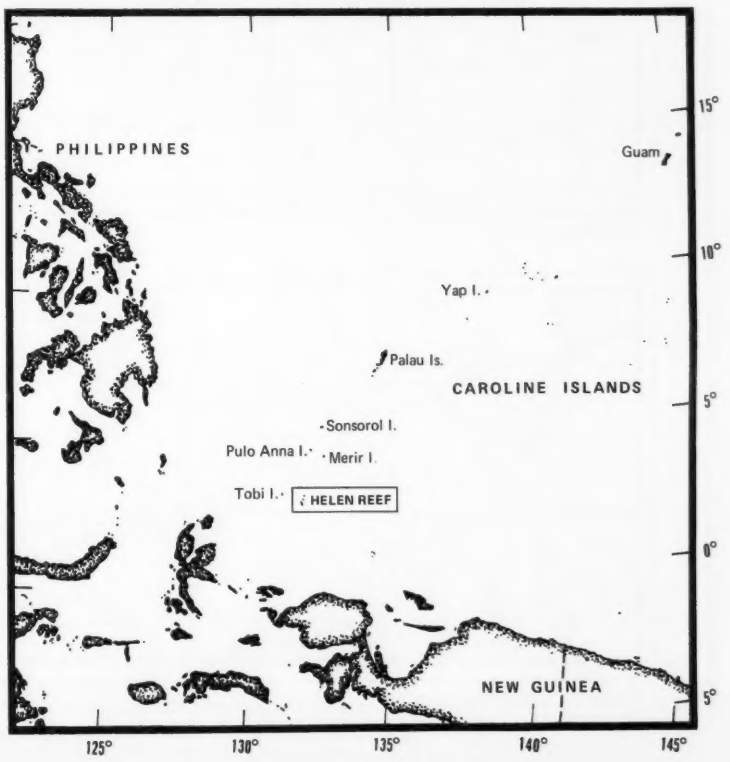
Natural History

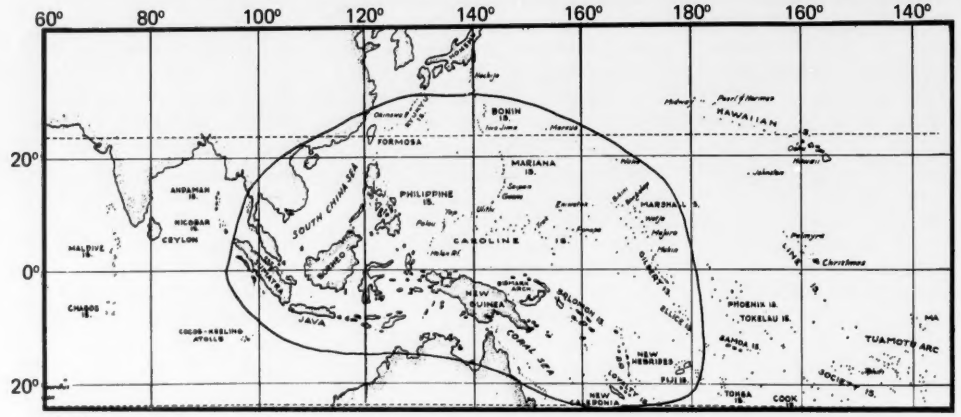
Because of its isolation, Helen Reef at one time supported large tridacnid clam populations. In one instance, Motoda (1938) reported observing approximately 38-46 *T. gigas* within 100 m^2. Although populations have been greatly reduced over the years, all six species of the Tridacnidae family still occur on Helen Reef: *T. gigas* (Linné), *T. derasa* (Röding), *T. squamosa* Lamarck, *T. maxima* (Röding), *T. crocea* Lamarck, and *Hippopus hippopus (Linné)*. These beautiful and sometimes colossal bivalves are found only in the Indo-Pacific faunal region (Fig. 3).

The two largest *Tridacna* species are *T. gigas* (Fig. 4a) and *T. derasa*. *Tridacna gigas* is the species usually referred to as the "giant clam," as old individuals may attain lengths of up to 135 cm (about 4½ feet). They usually occur on sandy areas of the reef or in areas of coral rubble and reef degeneration, within intertidal regions to approximate depths of 20 m. Although *T. gigas* exhibits a small byssus orifice, the adults remain unattached to any substrate. The dorsal margin and ribs exhibit deep undulation. *Tridacna derasa*, also a species capable of reaching large sizes, reportedly attain lengths of 50 cm (20 inches). These clams often live towards the outer edge of coral reefs and are usually unattached, although very young individuals (<10 cm length) develop weak byssal anchors. *Tridacna derasa* appear to prefer the more shallow reef areas (approximate depth range, 4-10 m).

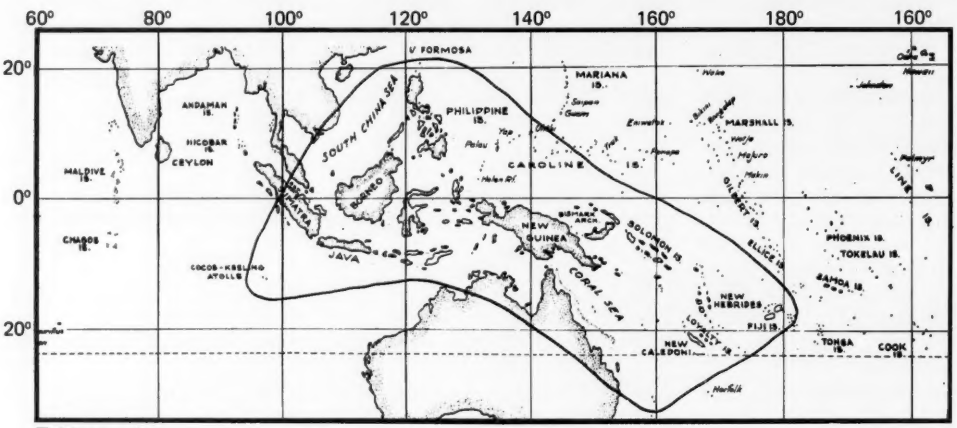
There are two slightly smaller tridacnids of commercial importance. *Tridacna squamosa* usually occurs on coral reef surfaces in depths less than 15 m, most often in protected environments such as reef canyons and fissures, sheltered lagoons, and marine lakes. These tridacnids are often referred to as "fluted clams" because of their characteristic broad, plate-like projections. In size, they can range up to 45 cm (over 17 inches). Although they are never imbedded, *T. squamosa* are often found nestled among coral and anchored with a weak but abundant byssus. *Hippopus hippopus* grow to 40 cm (close to 16 inches) in size and usually occur in sandy areas of the reef never more than 6 m in depth. Young *H. hippopus* attach by a weak, sparse byssus which disappears with age. These clams have heavy triangular shells and an undulating dorsal margin with very sharp, triangular, interdigitating processes.

Figure 2.—Palau District's southwest islands.

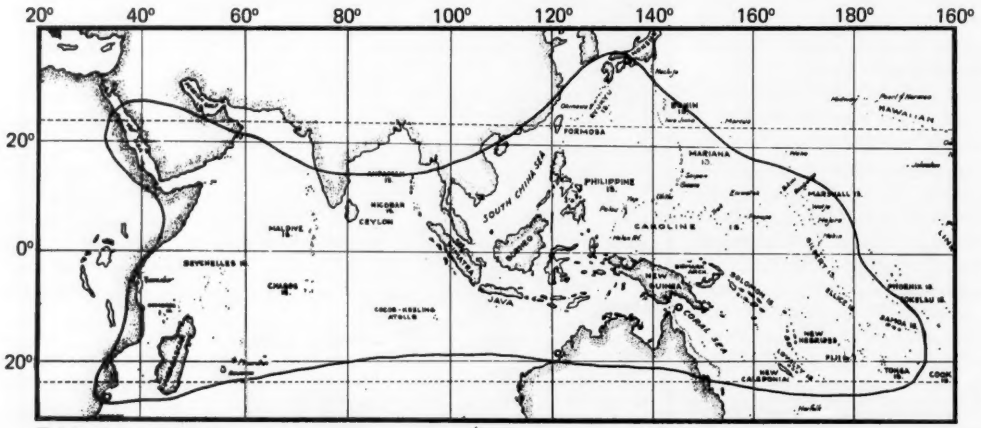




Tridacna gigas

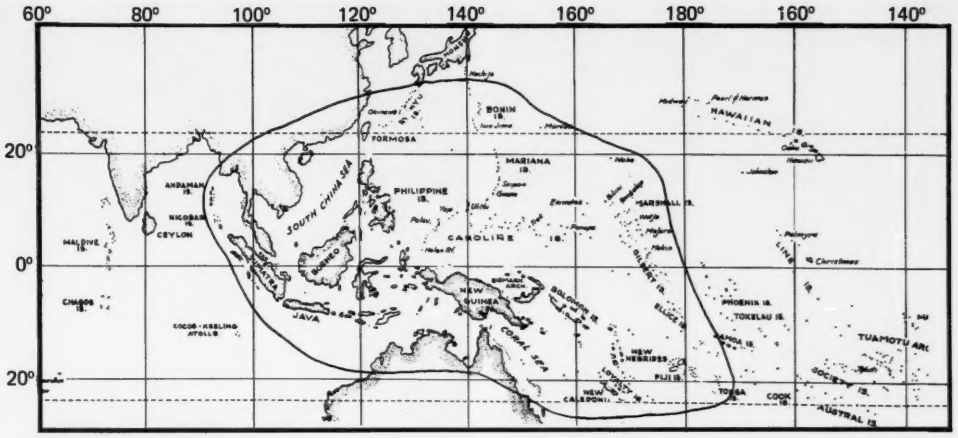


Tridacna derasa

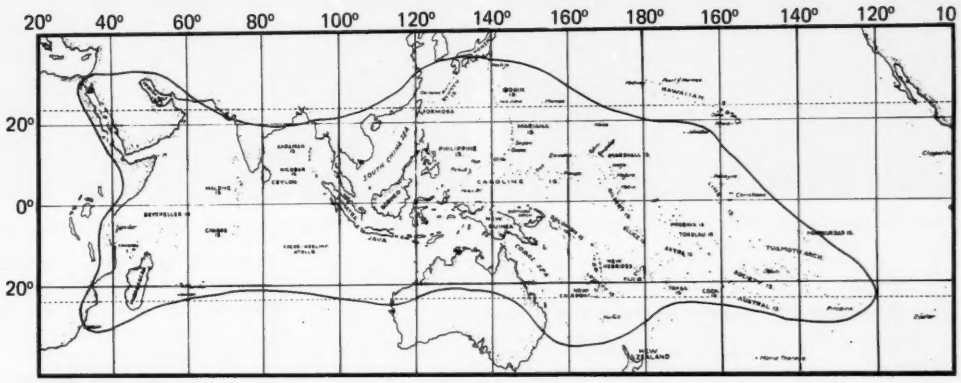


Tridacna squamosa

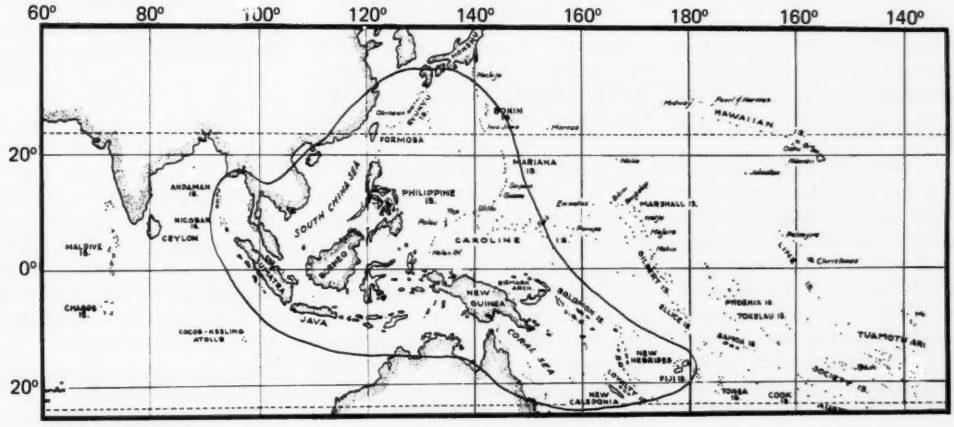
Figure 3.—Geographical ranges of tridacnid clams (from Rosewater, 1965).



Hippopus hippopus



Tridacna maxima



Tridacna crocea

Figure 3. — Continued.

Figure 4a.—*Tridacna gigas*, about 3 feet in length, on the reef at low tide.

Figure 4b.—*Tridacna maxima* partially embedded in coral.

The larger *Tridacna* species are the clams which are most often utilized by Palauans and foreign fishermen. The mantle and the adductor muscle tissues are highly favored food items, the larger clams producing a higher yield per expended fishing effort. Except for a small trade as a tourist item, shells are discarded.

The two smallest species, *T. maxima* (Fig. 4b) and *T. crocea*, are not usually harvested by foreign fishermen and are minimally used for food by Palauans. *Tridacna maxima* can grow to 35 cm (close to 14 inches). It can often be confused with *T. crocea*, but *T. maxima* is distinguished by its more triangular shape; its byssus keeps it firmly anchored halfway embedded in coral and coral heads. *Tridacna crocea* is the smallest species, approximately 15 cm (6 inches maximum) and is found completely embedded in coral heads on the reef flats and reef edge, remaining firmly anchored by a byssus.

Survey Methods

Attempts were made during the May 1976 survey to duplicate, as closely as possible, sampling locations and field methods used during the 1975 survey (Bryan and McConnell, 1976). Transect lengths were determined from the U.S. Navy Hydrographic Office Chart of Helen Reef, No. 6072. The same transects as reported by Bryan and McConnell (1976) were resurveyed. The bottom depths along transects varied from approximately 6 m on the ends, to a minimum of 1 m along the midsection. Two observers were pulled slowly behind a boat while all occurrences of live or dead tridacnid clams within a 2 m wide path below the boat were recorded on plastic writing tablets. Each biologist was responsible for counting two or three assigned clam species.

Total population sizes (N_j) for Helen Reef atoll were estimated by the equation (Cochran, 1963):

$$N_j = \left[\frac{\sum_{i=1}^{n} y_{ij}}{\sum_{i=1}^{n} l_i}\right] \frac{A}{w}$$

where Y_{ij} is the number of individuals of tridacnid clam species j observed along transect i, l_i is the length of transect i, w is the transect path width (= 2 m), and A is the total reef area (= 5.34×10^7 m^2; Hester and Jones, 1974), for n total transects.

Survey Results and Discussion

During the resurvey, we were able to repeat eight transects from the 1975 survey (Fig. 5). Summary data collected from the transects are presented

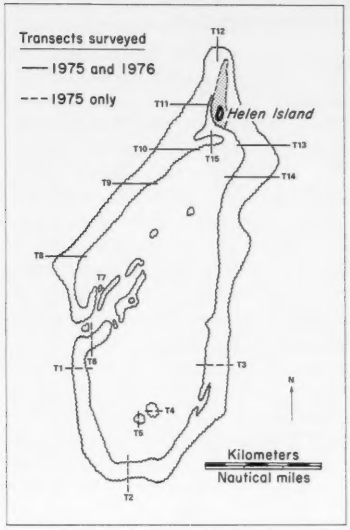


Figure 5.—Locations of sampling transects made on Helen Reef atoll, May 1976.

Table 1.—Summary of results from the 1976 survey of Helen Reef, Western Caroline Islands.

Transect	Location and direction of transect	Length of transect (m)	Area surveyed (m^2)	No. of live individuals counted	1976 Density of clams/100 m^2	[1]1975 Density of clams/100 m^2
T_8	lat. 2°54'42"N long. 131°45'14"E 270° true	970	1,940	3 *Hippopus hippopus* 61 *Tridacna maxima* — *T. derasa*	0.20 3.10 —	0.10 3.10 0.10
T_9	lat. 2°56'20"N long. 131°46'53"E 270° true	970	1,940	2 *H. hippopus* 1 *T. gigas* 2 *T. derasa* 34 *T. maxima* 1 *T. squamosa*	0.10 0.05 0.10 1.80 0.10	— — 0.10 2.00 0.10
T_{10}	lat. 2°58'00"N long. 131°48'16"E 270° true	1,130	2,260	5 *H. hippopus* 47 *T. maxima*	0.20 2.10	— 2.00
T_{11}	lat. 2°59'05"N long. 131°48'30"E 270° true	800	1,600	7 *H. hippopus* 1 *T. gigas* 1 *T. squamosa* 11 *T. maxima*	0.40 0.10 0.10 0.70	0.20 — — 2.7
T_{12}	lat. 3°00'30"N long. 131°48'55"E 0° true	645	1,290	26 *H. hippopus* 4 *T. maxima*	2.00 0.30	— 0.20
T_{13}	lat. 2°58'06"N long. 131°49'24"E 90° true	1,610	3,220	18 *H. hippopus* 2 *T. gigas* 4 *T. derasa* 1 *T. squamosa* 106 *T. maxima*	0.60 0.10 0.10 0.03 3.30	0.30 — 0.03 — 4.30
T_{14}	lat. 2°56'30"N long. 131°49'51"E 90° true	1,130	2,260	1 *H. hippopus* 1 *T. derasa* 11 *T. maxima*	0.04 0.04 0.50	0.30 — 0.20
T_{15}	lat. 2°58'00"N long. 131°49'00"E 180° true	480	960	1 *H. hippopus* 38 *T. maxima*	0.10 4.00	— 5.70

[1]Data from Bryan and McConnell (1976).

in Table 1; also included for comparison are the 1975 estimates for tridacnid population densities. In many instances, the 1975 and 1976 estimates were quite close. For each survey, the mean observed densities were expanded to provide estimates of the total populations on Helen Reef (Table 2). Because of the reduced survey size in 1976, estimates of standing stocks for 1975 were recalculated using only the eight northern transects that were resurveyed in 1976. This was done to allow a more direct comparison between the two survey results.

Table 2.—Stock estimates for tridacnids on Helen Reef, Western Caroline Islands.

Species	1972 Est. of standing stock[1]	1975 Est. of standing stock [2]	1975 Est. of standing stock from $T_8, \ldots, T_{15}$[3]	1976 Est. of standing stock[4]
Tridacna gigas	49.8×10^3	8.6×10^3	None observed	13.8×10^3 (4.7×10^3 – 22.9×10^3)
Tridacna derasa	32.8×10^3	12.9×10^3	14.1×10^3	24.2×10^3 (8.1×10^3 – 40.3×10^3)
Tridacna squamosa	1.2×10^3	4.3×10^3	3.5×10^3	10.4×10^3 (3.8×10^3 – 17.0×10^3)
Hippopus hippopus	44.6×10^3	47.4×10^3	70.5×10^3	217.5×10^3 (89.1×10^3 – 345.9×10^3)
Tridacna maxima	1.7×10^6	1.4×10^6	1.3×10^6	1.1×10^6 (0.7×10^6 – 1.4×10^6)
Tridacna crocea	3.7×10^6	Ubiquitous	Ubiquitous	Ubiquitous

[1]Data from Hester and Jones (1974).
[2]Data from Bryan and McConnell (1976), computed from all transects.
[3]Data from Bryan and McConnell (1976), computed from only the eight transects resurveyed in 1976.
[4]80 percent confidence limits in parentheses.

The 1972 estimates for the larger clams, *T. gigas* and *T. derasa*, were high compared with 1975 and 1976 estimates. These species showed a large reduction in apparent population sizes between 1972 and 1975. The apparent differences in the most recent stock estimates for *T. derasa* were relatively small and should be attributed to survey variation. Some transect variation is inevitable despite attempts to duplicate 1975 methods, which may help explain the observance of *T. gigas* in the northern transects during the 1976 survey and the absence of observation in 1975. Recruitment can also be a consideration when observing population fluctuations but the extent that apparent increases were caused by recruitment remains unknown. Table 3 presents a comparison of the ratios of live and dead individuals for the two most recent surveys. In 1976, both species still showed large numbers of dead individuals, although the proportions of dead individuals were slightly less than 1975, especially for *T. derasa*. All empty shells of *T. gigas* and *T. derasa* observed were heavily encrusted with marine organisms, displaying little evidence of recent harvesting.

Tridacna squamosa has been reported at low densities during all previous surveys. In 1972, Hester and Jones (1974) observed only one *T. squamosa*; in 1975, Bryan and McConnell (1976) counted only two individuals. These earlier investigators indicated that this

tridacnid species is either very rare or not easily distinguished from *T. maxima* in this particular environment. During the 1976 survey, however, the two species were readily distinguished. Although three individuals of *T. squamosa* were identified, their densities were still low compared with all other species. *Tridacna squamosa* appears to prefer relatively protected areas, so wave exposure may be a limiting factor for *T. squamosa* at Helen Reef. Although their relatively large size would make them desirable for harvesting, since only one dead individual was observed in 1975, their population was apparently not strongly affected by this activity.

The 1976 survey showed a substantial increase in the apparent abundance of *H. hippopus*, compared with the 1972 and 1975 surveys, but the ratio of dead individuals to empty shells was still high. This species is characteristically very angular in appearance with dusky, sandy mantle tones. Their cryptic coloration makes them one of the more difficult tridacnids to count in the field, perhaps contributing to an underestimation of abundance by earlier investigators.

The most curious condition observed during the 1976 survey was the absence of large numbers of empty shells reported by Bryan and McConnell (1976). Foreign fishing boats had been observed in the area between the 1975 and 1976 surveys, possibly taking shells for the tourist market. Alternatively, heavy seas and rough weather could have broken up old shells and swept them off the reefs.

The two smallest tridacnid species have shown little variation in apparent population densities over the years. The small *T. maxima* have shown low variance in stock size, with very little variation in apparent densities from 1972 through 1976. The ubiquitous *T. crocea* was not surveyed in 1975 and 1976 because of the small size of individuals and high population densities. Large coral heads can be embedded with many *T. crocea*, and it would take much time and a more detailed sampling effort to survey this species reliably. Therefore, its presence in large numbers was only noted during the 1975 and 1976 surveys. Lack of fishing pressure may allow these smallest tridacnids to maintain a more constant population size.

Table 3.—Comparison of the number of live and dead tridacnid clams observed during the 1975 and 1976 surveys, Helen Reef, Western Caroline Islands.

Species	1975[1]		1976	
	Ratio of live: dead individuals	Percent dead	Ratio of live: dead individuals	Percent dead
Tridacna gigas	4:206	98.1	4:47	91.5
Tridacna derasa	6:168	96.6	7:24	70.8
Tridacna squamosa	2:1	33.3	3:0	0
Hippopus hippopus	22:458	95.4	63:39	38.1
Tridacna maxima	629:23	3.5	312:5	1.6
Tridacna crocea	Ubiquitous	—	Ubiquitous	—

[1]Data from Bryan and McConnell (1976).

Table 4.—Comparison of the number of live tridacnids counted in 1975 along transects in north (transects 8 to 15) and south (transects 1 to 7) regions of Helen Reef, Western Caroline Islands (from Bryan and McConnell, 1976).

Species	Live individuals counted in north reef transects	Live individuals counted in south reef transects	Percent located in north reef transects
Tridacna gigas	0	4	0
Tridacna derasa	4	2	66.7
Tridacna squamosa	1	1	50.0
Hippopus hippopus	20	2	90.9
Tridacna maxima	367	262	58.3
Tridacna crocea	Ubiquitous	Ubiquitous	—

In Table 4 a comparison was made between the numbers of live tridacnids found in north and south areas of the reef in 1975 to examine the influences of large-scale distribution on population estimates. The reef was sampled by transects 8-15 in the north and by transects 1-7 in the south. Transects 8-15 in the north correspond to the areas that were resurveyed in 1976. The percentage of clams located in the northern eight transects in 1975 was calculated for each species. There appeared to be differences among some of the tridacnids in location preference. In 1975, *T. gigas* was observed only in the south, while almost 91 percent of *H. hippopus* were found in the north. Since *T. gigas* is usually quite visible, the apparent skewed distribution may only be a product of sampling variability since only small numbers of this species were observed. It is possible that a preference for the south reef area may exist but it is impossible to verify from this survey. This apparent preference for the north reef region by *H. hippopus* would contribute to a population overestimation in the 1976 survey. Other species appeared to be relatively evenly represented in both north and south regions.

Excluding *T. maxima* and *T. crocea* because of their lack of value to foreign fishermen, less than half (43.6 percent) the tridacnid clams observed on Helen Reef in 1975 were alive. In 1976, the conditions were much the same with only 40.1 percent of the clams surveyed alive. In natural reef environments, it is unusual to see so many empty shells unless fishing pressures have been high. Large percentages of empty shells have been observed following concentrated fishing activities (Motoda, 1938; Bryan and McConnell, 1976). Because of the lack of fishing pressure on the smaller species, perhaps *T. maxima*, and maybe *T. crocea*, indicate the normal ratios of live to dead individuals representative of tridacnid populations subject only to natural sources of mortality.

In May 1976, the effects of recent harvests were evident at Helen Reef

with tridacnid populations reduced from much higher levels of abundance (Motoda, 1938; Hester and Jones, 1974). The conditions of the clam resources observed in 1976 emphasized the need to prevent their further uncontrolled harvesting, especially since most of the clams observed in 1976 appeared smaller than the mean sizes reported in 1972 (Hester and Jones, 1974). Because the recruitment of tridacnid clams appears to be slow and irregular, large population depletions could have serious long-term effects. Wada (1952, 1954) suggested that because of the nature of spawning behavior in tridacnid clams, self-fertilization rarely occurs. Other observations have also shown no normal larval development after attempts at self-fertilization. If this is the case, then there may be some minimum threshold density from which reduced populations would be unable to recover.

Harvests of tridacnid clams from Helen Reef should continue to be restricted until increases in stock abundances have been observed and documented. Additional research is needed to determine allowable clam harvest levels, threshold densities, and stock recovery rates.

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Per Capita Annual Utilization and Consumption of Fish and Shellfish in Hawaii, 1970-77

LINDA L. HUDGINS

Introduction

In 1977, the U.S. per capita consumption of edible (meat-weight) fish and shellfish was 5.82 kg (12.8 pounds). It has been speculated that the per capita consumption of fishery products in the State of Hawaii is considerably higher than the U.S. average. No studies have been done to verify this speculation.

This paper is an attempt to quantify the actual consumption in Hawaii for the period 1970-77. This quantification required computation of the total supply of fish and fishery products available in Hawaii. The total supply was then adjusted to edible weight and divided by the population. The result is that the per capita consumption rate in Hawaii for 1977 was about 77 percent higher than the U.S. average.

Foreign imports represented, in 1977, approximately 54 percent of the total supply of fish and shellfish in Hawaii. Therefore, a section and tables are included in which these imports are disaggregated by quantity, value, and type of preparation for 1970-77; and by major product and major country of origin for 1976 and 1977.

An effort was made to calculate the per capita figures with the same methodology as that used in "Fisheries of the United States" (Bell, 1978) where national per capita estimates are published. The units of quantity and measurement in this report are not exactly comparable in some cases. These measurement discrepancies, as indicated in the table notes, should not hinder the usefulness of these preliminary estimates, however.

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Data and Methods

The State of Hawaii has three major sources of commercial fish and fishery products for human consumption: 1) Local catch, 2) imports from foreign countries, and 3) interstate shipments from the mainland United States. Table 1 gives totals for these sources. Hawaii landings are shown in round (live) weight as reported by the vessels to the State of Hawaii, Division of Fish and Game. Foreign imports and interstate shipments are in net product weight, as recorded at the port by U.S. Customs officials and published by the U.S. Bureau of the Census (1970-77) and the U.S. Army Corps of Engineers (1970-77).

Hawaii per capita utilization of fish and shellfish (Table 2) is determined using total supply of fishery products without adjustment for beginning or ending stocks, foreign exports, or defense purchases. Table 3 gives a comparison of the United States and Hawaii per capita utilization rates. Table 4 gives U.S. per capita consumption of fish and shellfish as published by the National Marine Fisheries Service.

Hawaii per capita consumption in Tables 5-7 is based on pounds of edible (meat-weight) fish. Figures for Hawaii in Tables 5-7 are adjusted for foreign exports of fish and shellfish and shipments of canned tuna and fresh and frozen fish to the mainland United States. Supply of cured fish for consumption includes fish dried, salted, smoked, or kippered whether canned or not. Cured supply does not include local production of cured fishery products. Raw inputs for local production are counted under fresh, frozen, or chilled. Supply of canned fish for consumption includes fish of all preparations in airtight containers, most of which are cans.

The State of Hawaii has three variable components of population in addition to the civilian resident population: Military, visitors, and foreign immigrants. Military includes those who are serving in the armed forces and either actually residing in Hawaii or stationed aboard a ship homeported in Hawaii. Since 1971, the military has stabilized at around 6 percent of total de facto population (those actually present in the State). Military dependents are counted as part of the resident civilian population. There are approximately 1.15 dependents per military member in Hawaii. Visitor population, estimated by the Hawaii Visitors Bureau, during 1978 was around 9 percent of the total population based on the annual average number of visitors present. Approximately 8 percent of the civilian resident population of Hawaii in 1970 were

Table 1.—Total Hawaii supply of commercial fish and shellfish, in thousands of pounds, by source and year, 1970-77.[1]

Year	Local commercial landings[2]	Foreign imports[3]	Interstate shipments[4]	Total
1970	11,282.3	22,960.3	5,896.0	40,138.6
1971	17,159.8	18,681.3	5,764.0	41,605.1
1972	14,754.7	28,953.6	4,682.0	48,390.3
1973	14,382.4	21,346.9	3,950.0	39,679.3
1974	11,323.7	24,467.2	4,068.0	39,858.9
1975	9,724.5	22,015.6	4,362.0	36,102.1
1976	15,272.3	19,846.3	4,094.0	39,212.6
1977	13,783.4	30,991.3	7,650.0	52,424.7

[1]Based on the total supply of edible fishery products, without taking into consideration beginning or ending stocks, exports, or defense purchases.
[2]State of Hawaii, Department of Land and Natural Resources, Division of Fish and Game. Reports in round weight.
[3]U.S. Bureau of the Census (1970-77). Reported in net product weight.
[4]U.S. Army Corps of Engineers (1970-77). Reported in net product weight.

Table 2.—Per capita utilization of commercial fish and shellfish in Hawaii by year, source of fish, and two population groups, 1970-77.

	Resident civilian and military population						Resident civilian, military, and visitor population				
				Per capita utilization					Per capita utilization		
Year	Total resident civilian and military population, 1 July (1,000 persons)[1]	Armed forces (1,000 persons)	Total Hawaii supply (1,000 lb)[2]	Local commercial catch	Interstate shipments and foreign imports	Total	Total resident civilian and military plus visitor population (1,000 persons)[1]	Visitors present (annual average) (1,000 persons)	Local commercial catch	Interstate shipments and foreign imports	Total
1970	775.8	53.2	40,138.6	14.5	37.2	51.7	803.4	37.6	14.1	35.9	50.0
1971	800.9	50.8	41,605.1	21.4	30.5	51.9	833.3	41.9	20.7	29.3	50.0
1972	823.3	52.0	48,390.3	17.9	40.9	58.8	865.9	51.3	17.0	38.9	55.9
1973	844.1	58.1	39,679.3	17.0	30.3	47.3	895.9	61.6	16.1	28.2	44.3
1974	855.4	57.5	39,858.9	13.2	33.4	46.6	913.6	66.0	12.4	31.2	43.6
1975	867.9	58.9	36,101.9	11.2	30.4	41.6	927.7	68.8	10.5	28.4	38.9
1976	883.5	57.8	39,212.6	17.3	27.1	44.4	952.7	78.5	16.0	25.2	41.2
1977	894.7	56.5	52,424.7	15.4	43.2	58.6	972.5	86.8	14.3	39.7	54.0

[1] Hawaii. Department of Planning and Economic Development (1978:6).
[2] Table 1, unadjusted for beginning and ending stocks, exports, or defense purchases. Excludes imports of nonedible fishery products.

Table 3.—United States and Hawaii total supply (million pounds) and per capita utilization (pounds) of commercial fish and shellfish by year, 1970-77.

	Total supply[1]		Total per capita utilization[2]	
Year	U.S.	Hawaii	U.S.[3]	Hawaii
1970	11,474	41.13	56.0	51.7
1971	11,804	43.11	57.0	51.9
1972	13,849	49.68	66.3	58.8
1973	10,378	40.94	49.3	47.3
1974	9,875	40.85	46.6	46.6
1975	10,129	36.95	47.4	41.6
1976	[4]11,555	40.55	53.7	44.4
1977	[4]10,579	53.63	48.8	58.6

[1]Total supply for U.S. includes nonedible and industrial fishery products not included in total supply for Hawaii.
[2]Population is total resident civilian and military population present on 1 July.
[3]Bell (1978:70).
[4]Preliminary.

Table 4.—United States per capita consumption of commercial fish and shellfish by year and three types of preparation, 1970-77.[1]

		Per capita consumption (lb)			
Year	Civilian resident population (million persons)	Fresh and frozen	Canned	Cured	Total
1970	201.7	6.9	4.5	0.4	11.8
1971	204.3	6.7	4.3	0.5	11.5
1972	206.5	7.2	4.9	0.4	12.5
1973	208.1	7.5	5.0	0.4	12.9
1974	209.7	7.0	4.8	0.4	12.2
1975	211.4	7.4	4.3	0.4	12.1
1976	[2]213.0	8.2	4.3	0.5	13.0
1977	[2]214.7	7.8	4.6	0.4	12.8

[1]Bell (1978:72).
[2]Preliminary.

Table 5.—Hawaii per capita consumption[1] of commercial fish and shellfish by year and three categories of preparation, 1970-77.

	Total civilian resident population 1 July (1,000 persons)	Per capita consumption (lb)			
Year		Fresh and frozen	Canned[2]	Cured[3]	Total
1970	722.6	19.4	5.3	1.0	25.7
1971	750.1	20.5	4.6	0.7	25.8
1972	771.3	17.1	6.6	0.8	24.5
1973	785.9	16.7	3.8	0.9	21.4
1974	797.9	14.0	4.7	0.6	19.3
1975	809.0	15.3	3.6	0.7	19.6
1976	825.7	15.3	4.3	0.8	20.4
1977	838.3	17.8	4.0	0.9	22.7

[1]Unadjusted for beginning and ending inventories and military purchases. Adjusted for exports to foreign countries from the Honolulu Customs district.
[2]Includes preserved and prepared which are canned but not included in cured.
[3]Does not include local production.

Table 6.—Hawaii per capita consumption of commercial fish and shellfish by year and three types of preparation, 1970-77 including annual average visitor population.[1]

	Total civilian resident population plus visitors 1 July (1,000 persons)	Per capita consumption (lb)			
Year		Fresh and frozen	Canned[2]	Cured[3]	Total
1970	760.2	18.9	5.0	0.9	24.8
1971	792.0	19.4	4.3	0.7	24.4
1972	822.6	16.0	6.2	0.8	23.0
1973	847.5	15.5	3.5	0.9	19.9
1974	863.9	12.9	4.4	0.9	18.2
1975	877.8	14.1	3.4	0.6	18.1
1976	904.2	14.0	3.9	0.7	18.6
1977	925.1	16.1	3.6	0.8	20.5

[1]Unadjusted for beginning and ending inventories, and military purchases. Adjusted for exports from the Honolulu Customs district.
[2]Includes preserved and prepared which are canned but not included in cured.
[3]Does not include local production.

foreign born persons from the People's Republic of China, Taiwan, Japan, Korea, and the Philippines. All of these countries have substantially higher per capita fish consumption rates than that of the United States (Bell, 1978:74). These three components of population may account for over 20 percent of the actual population present in the State at

a given time. For this reason, per capita consumption was calculated for various measures of population which would include these groups.

Table 7.—United States and Hawaii total per capita consumption (pounds) of commercial fish and shellfish by year, 1970-77.[1]

Year	Total per capita consumption	
	U.S.	Hawaii[2]
1970	11.8	25.7
1971	11.5	25.8
1972	12.5	24.5
1973	12.9	21.4
1974	12.2	19.3
1975	12.1	19.6
1976	[3]13.0	20.4
1977	[3]12.8	22.7

[1]Population is total civilian resident population.
[2]Unadjusted for beginning and ending inventories and military purchases.
[3]Preliminary.

Foreign Imports

Imports from foreign countries in 1977 represented 54 percent of the total supply of fish, fishery products, and shellfish in Hawaii. Table 8 gives these imports by year and type of preparation, aggregated over countries. All of these products are designated for human consumption. Values are unadjusted and reflect customs values. Customs value generally represents a value in the foreign country, and therefore excludes U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise to the United States. This value may not reflect the actual transaction value.

Table 9 gives imports to Hawaii of fresh, frozen, or chilled fish and shellfish by major country of origin, quantity, and customs value. Relative rankings of these countries vary between 1976 and 1977. However, the major five countries (New Hebrides, Philippines, Taiwan, Japan, and Panama) are the same for both years. Fiji had no recorded exports to Hawaii in these categories for 1977.

Table 10 gives imports to Hawaii "in cans or airtight containers." Shellfish and anchovies are the major products. In 1972, the major sardine exporting countries were Brazil, United Kingdom, and Denmark. In 1973, only Denmark is recorded as exporting sardines to the Honolulu customs district which is reflected in the much lower 1973 figure. The category marked "other" in this and subsequent tables represents other species which the U.S. Customs aggregates under the heading "not elsewhere specified."

Table 8.—Foreign imports to Hawaii of fish and fish products for human consumption by year, type of preparation, quantity and customs value,[1] 1970-77.

Year	Total		Fresh, chilled, frozen		Cured		Fish in airtight containers		Fish products (pastes, balls, sticks, roe)		All shellfish	
	Quantity (1,000 lb)	Value ($1,000)	Quantity (1,000 lb)	Value ($1,000)	Quantity (1,000 lb)	Value ($1,000)	Quantity (1,000 lb)	Value ($1,000)	Quantity (1,000 lb)	Value ($1,000)	Quantity (1,000 lb)	Value ($1,000)
1970	22,906.3	10,354.8	19,417.9	6,376.9	81.1	78.4	422.1	215.5	481.7	374.8	2,557.5	3,309.2
1971	18,681.2	10,633.1	13,893.0	5,146.2	85.0	86.8	974.3	397.7	810.0	479.1	2,919.0	4,523.3
1972	28,953.6	15,755.6	23,693.8	9,816.9	85.8	147.0	1,317.9	497.3	1,123.5	609.3	2,732.8	4,685.1
1973	21,346.9	13,633.5	16,496.5	7,703.3	119.5	212.9	853.3	381.4	1,222.8	878.9	2,654.9	4,457.0
1974	24,467.2	17,303.3	19,340.0	10,182.8	113.4	145.3	767.5	501.6	1,342.7	854.2	2,903.6	5,619.4
1975	22,015.6	13,393.4	17,320.0	7,815.2	87.0	119.9	816.1	433.1	1,583.2	1,114.0	2,208.8	3,911.1
1976	19,846.3	14,185.4	14,917.3	7,380.1	131.0	163.3	877.3	500.5	1,634.0	1,118.4	2,286.7	5,023.1
1977	30,991.3	22,875.4	26,448.9	15,729.3	94.8	152.6	746.2	521.2	1,387.4	1,151.2	2,314.0	5,321.1

[1]Customs value generally represents a value in the foreign country, and therefore excludes U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise to the United States. This value may not reflect the actual transaction value. These values are unadjusted.

Table 9.—Imports of fresh, frozen, chilled fish and shellfish by major countries of origin,[1] quantity, and customs value,[2] 1976 and 1977.

Country of origin	1976		1977	
	Quantity (1,000 lb)	Customs value ($1,000)	Quantity (1,000 lb)	Customs value ($1,000)
Fish				
New Hebrides	6,016.9	3,216.3	19,014.7	11,991.0
Philippines	23.6	19.5	3,345.9	865.4
Taiwan	1,876.1	1,411.3	2,749.4	2,019.6
Japan	1,070.7	742.1	727.2	534.2
Panama	3,856.0	1,104.0	185.5	55.7
Fiji	1,180.0	538.7	—	—
Shellfish				
New Zealand	248.1	1,407.9	213.0	1,514.0
Taiwan	134.7	457.5	93.6	369.0
Japan	42.3	129.3	18.6	61.4

[1]Country of origin as determined by U.S. Customs.
[2]See footnote 1, Table 8.

Table 10.—Foreign imports to Hawaii of fishery items, canned and in airtight containers, all manner of preparation, net weight in thousand pounds, 1970-77.

Year	Salmon	Sardines	Tuna	Anchovies	Shellfish	Other	Total
1970	18.6	45.0	95.0	54.6	1,323.6	208.9	1,745.7
1971	45.9	182.5	85.6	153.3	1,218.7	507.0	2,193.0
1972	68.2	389.5	55.2	228.4	1,247.0	576.6	2,564.9
1973	(1)	26.9	78.7	242.1	1,225.5	506.0	2,079.2
1974	11.6	21.8	120.0	213.1	1,898.8	401.0	2,666.3
1975	(1)	6.5	112.0	358.5	1,315.9	339.0	2,131.9
1976	(1)	34.3	139.3	355.7	1,319.8	348.0	2,197.1
1977	11.6	44.2	29.6	305.3	1,243.4	355.5	1,989.6

[1]None reported.

Table 11 reflects edible fishery products by major type of preparation. Tuna, fish fillets, and shellfish compose over 90 percent of the total fresh and frozen imports to Hawaii for 1976 and 1977. The itemized entries under "canned" for 1976 reflect over 60 percent of the total quantity of canned imports to Hawaii and for 1977 over 78 percent. The category "Other fish and shellfish" reflects the sum over type of preparation of the "not elsewhere classified" specifications.

Table 12 represents estimated per capita consumption of foreign imports by type of preparation, adjusted to pounds of edible fishery products divided by civilian resident population of Hawaii on 1 July of each year.

Summary and Conclusions

The tabulated data show that the total per capita consumption of fish and shellfish in the State of Hawaii has been higher than the U.S. average over the entire period 1970-77. Specifically, the following conclusions can be drawn about fish and shellfish consumption:

1) United States per capita total consumption has followed a slight upward trend—from 1973 to 1977, consumption varied between 5.45 and 5.91 kg (12 and 13 pounds).

2) Hawaii per capita consumption for all fish products followed an unclear trend over the period. Consumption declined dramatically from 1972 [11.14 kg (24.5 pounds)] to 1974 [8.77 kg (19.3 pounds)] and has since followed a solid upward trend.

3) Per capita consumption of fresh and frozen fishery products in Hawaii has ranged from 206 percent (in 1971) to 87 percent (in 1976) above the national average.

4) Per capita consumption of canned fishery products in Hawaii since 1973 has been below the U.S. average.

5) Per capita consumption of cured fishery products in Hawaii has been above the U.S. average for the period. Since this does not include local Hawaii production, the cured fishery products consumption rate in Hawaii is actually higher than the data indicate.

These results show that the most pronounced decline in the 1972-74 period occurred in the fresh and frozen category. During this time, factors which may have possibly caused the decline were: 1) A change in tastes due to the public concern over high mercury content in large pelagic fishes. Market observers during this period report that the local fishermen were unable to sell many of their fish and that it is conceivable it would have taken several years for the consumers to return to their higher preference levels for fish. 2) The observed reduction in the quantity of local supply during 1972-74 was possibly a result of a decline in demand due to a change in tastes. 3) At the same time (1972) the visitor population began to grow much faster (12.2 percent annually) than the civilian resident population (2.1 percent annually). This visitor population may exhibit differential consumption rates that are higher or lower than the

Table 11.—Foreign imports of edible fishery products to Hawaii, by principal items, 1976 and 1977.

Item	1976		1977	
	1,000 lb	$1,000[1]	1,000 lb	$1,000[1]
Fresh and frozen				
Tuna				
Albacore	5,177.6	2,980.8	14,959.8	10,183.9
Skipjack	2,200.2	627.5	2,343.7	598.7
Yellowfin	4,136.3	1,507.9	5,287.8	2,158.9
Fillets	2,494.1	1,832.1	3,253.1	2,358.4
Shellfish				
Clams	29.2	27.8	17.3	26.6
Lobsters	297.6	1,619.8	245.5	1,654.9
Shrimp and prawns	242.9	779.2	137.5	486.9
Other	948.6	551.5	637.4	576.2
Canned				
Salmon	0	0	11.6	22.6
Anchovies	355.7	94.0	305.3	94.4
Sardine				
Not in oil	23.9	8.0	43.7	25.3
Tuna	139.3	128.3	29.6	35.2
Bonito and yellowtail	3.1	7.5	2.2	6.1
Clams	182.1	234.0	174.8	275.7
Shrimp	31.4	57.9	50.5	104.9
Other	510.0	549.5	474.4	768.4
Cured				
Pickled, salted, or dried	577.8	1,078.5	719.2	1,278.6
Smoked or kippered	81.3	80.5	57.1	80.4
Other fish and shellfish	2,415.2	2,020.6	2,240.8	2,139.1
Total edible fishery products	19,846.3	14,185.4	30,991.3	22,875.2

[1]See footnote 1, Table 8.

Table 12.—Estimated Hawaii per capita consumption of foreign imports of fish, fishery products, and shellfish by year and type of preparation, 1970-77.[1]

Year	Total civilian resident population, July 1 (1,000 persons)	Per capita consumption (lb)					
		Fresh, chilled, frozen[2]	Dried, salted, pickled, smoked, kippered	Fish in airtight containers	Pastes, balls, sticks	Shellfish	Total
1970	722.6	6.2	0.1	0.6	0.7	0.5	8.1
1971	750.1	4.8	0.1	1.3	1.1	0.7	8.0
1972	771.3	5.5	0.1	1.7	1.5	0.7	9.5
1973	785.9	5.0	0.2	1.1	1.6	0.5	8.4
1974	797.9	3.4	0.1	1.0	1.7	0.4	6.6
1975	809.0	4.7	0.1	1.0	2.0	0.4	8.2
1976	825.7	3.8	0.2	1.1	2.0	0.4	7.5
1977	838.3	2.0	0.1	0.9	1.7	0.3	5.0

[1]Unadjusted for exports, defense purchases, or beginning or ending stocks.
[2]Based on imported weight which is net product weight. In some cases this is meat-weight; in others, this is whole or round weight. Customs reports only net product weight.

resident population. However, any effect other than an absolute increase in the population is indeterminant. A diminished supply of fresh fish combined with a larger population base would result in a lower observed per capita consumption rate.

Hawaii has a large recreational fishery. The decline in the fresh category may be modified when consumption by recreationalists that is not reported in the commercial catch is taken into consideration. Yearly data for recreational landings as a separate category are not available. A recent study[1] used Kailua-Kona, Hawaii, survey information to estimate gamefish catch by commercial and recreational troller vessels for 1976. The authors' "Estimate I" (Table 4) represents an adjustment to statewide Division of Fish and Game data which accounts for underreporting and differential vessel catch rates by vessel category. When this estimate was considered, the total Hawaii supply of fish and fishery products (for 1976) increased from 17,829,909.1 kg (39,212,600 pounds) to 18,432,090.9 kg (40,550,600 pounds), per capita consumption of fresh and frozen fish increased from 6.95 kg (15.3 pounds) to 7.32 kg (16.1 pounds), and total Hawaii per capita consumption increased from 9.27 kg (20.4 pounds) to 9.64 kg (21.2 pounds).[2] Consumption of canned and cured fish are unaffected. It should be noted that the above estimate should therefore be considered as an approximation of one component of total recreational catch, that component caught by troller vessels and sold. Recreational catch that is not sold does not have to be reported.

Estimates of per capita consumption rates and the trends of these rates provide valuable input to research and policy planning. Specific determinants of this consumption have not been addressed here. However, these results have implications in particular for the Hawaii fishing industry, the aquaculture development program in Hawaii, the State of Hawaii Fisheries Development Plan, and Regional Fishery Management Plans.

[1]Cooper, J. C., and M. F. Adams. 1978. Preliminary estimates of catch, sales, and revenue of game fish for the fishery conservation zone around the main Hawaiian Islands, by types of troll and longline vessels and by species, 1976. Unpubl. rep., 10 p. Southwest Fisheries Center Admin. Rep. 24H, Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

[2]Population is total resident civilian.

Acknowledgments

I wish to thank Michael F. Adams and Roy Mendelssohn of the Honolulu Laboratory, Southwest Fisheries Center, NMFS, NOAA, and Girol Karacaoglu of Victoria University of Wellington, N.Z., for their comments and assistance. I especially wish to thank Ronald Sakamoto, U.S. Customs Import Specialist, Honolulu Customs District, for patiently and frequently sharing his expertise during the research portion of this project.

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Polychlorinated Biphenyls in Fish and Shellfish of the Chesapeake Bay

MAX EISENBERG, REBA MALLMAN, and HASKELL S. TUBIASH

Introduction

Polychlorinated biphenyls (PCB's) were first synthesized in 1881 and prepared commercially in 1930 when physical characteristics and potential industrial applications were described (Standen, 1964). Since then they have been universally employed and highly regarded for their wide spectrum of useful chemical and physical properties, including low vapor pressure at ambient temperatures, resistance to combustion, remarkable chemical stability, high dielectric constant, high specific electrical resistivity, low water solubility, and high lipid solubility.

PCB's are synthesized commercially by controlled chlorination of biphenyls with anhydrous Cl_2 in the presence of iron filings or $FeCl_3$ as a catalyst, yielding a mixture of PCB's and HCl. The PCB's are identified by a four digit numbering code, the first two digits representing the molecular type, while the last two digits give the weight percent of chlorine (Fig. 1). Thus Aroclor 1254 (Monsanto)[1], is a 1-2 chlorinated biphenyl containing 54 percent chlorine. The line of biphenyls available from Monsanto, for example, ranged from 21 to 68 percent chlorine. Two hundred nine possible chlorobiphenyl isomers exist (Mieure et al., 1976).

Highly chlorinated PCB's are white crystalline solids, while the lower chlorinated compounds are clear, viscous liquids, the viscosity increasing with increased chlorine content. Practically, PCB's seldom appear as pure compounds, but rather as mixed isomers. The characteristics of PCB's which make them particularly suitable for industrial use are their thermal and chemical stability. Ironically, it is exactly these properties, plus the fact that PCB's are readily absorbed and concentrated as they proceed up the trophic levels of the food web, which makes them so environmentally hazardous.

As universal contaminants, PCB's have essentially the same distribution pattern as DDT. The ubiquitous presence of PCB's is partly explained by the range and diversity of their utility, which has been so extensive that scarcely anyone can or has escaped their contact.

Since 1971, the employment of PCB's has been closely restricted and at present they are principally used in "closed-system" transformers and capacitors. But prior to 1971, approximately 40 percent of U.S. PCB production went into such "open" applications as plasticizers, hydraulic fluids, lubricants, sealants, and adhesives; as laminates in the fabrication of safety glass, ceramics, and metals; and as additives in paints, varnishes, putties, and

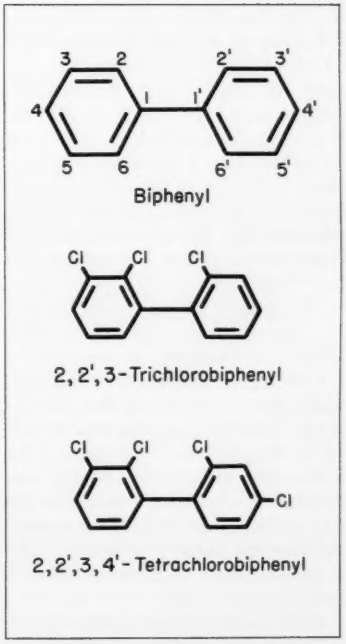

Figure 1.—Numbering system for biphenyl structure (from Mieure et al., 1976).

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[1]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

ABSTRACT—Polychlorinated biphenyls (PCB's) are a class of persistent, highly stable, almost universally distributed toxic industrial chemicals with an affinity for fatty tissues of terrestrial and aquatic animals. Their use other than in closed-system electrical applications, such as transformers and capacitors, is banned in the United States. In 1976, a survey of approximately 300 samples of mollusks and finfishes from 100 stations in the Maryland portion of the Chesapeake Bay and its tributaries revealed no instances of PCB levels exceeding or approaching generally accepted safe levels.

caulking compounds. They were incorporated into washable wall coverings and upholstery materials, and were widely used for flame- and waterproofing canvas and synthetic yarns.

After serving such expendible uses, such PCB's became (and continue to become) "lost" into the environment whsre they infiltrate the biosphere and continue to resist degradation. Since PCB's were used extensively in printing inks and dye microencapsulation for carbonless duplicating papers, these persistent agents thereby still find a ready entry into recycled paper and paper products.

As chemical toxicants, PCB's are unique since, unlike most other persistent contaminants (i.e., pesticides), they were never consciously distributed into the environment.

Effects on Humans

The deleterious effects of PCB's on human health became evident in 1968 when a Japanese rice oil became massively contaminated with PCB leaking through a defective heat exchanger (Kuratsume, 1976). Over 1,000 clinical cases of the new disease called "kanemi yusho" (literally "oil disease") occurred with an estimated subclinical exposure of up to 15,000 subjects. In this episode involving Kanechlor 400, a Japanese manufactured PCB, the average clinical case ingested about 2,000 mg of PCB. It was estimated that the minimum dose for breeching the clinical horizon was 500 mg ingested over 50 days—approximately 200 μg/kg body weight per day (Higuchi, 1976; Kuratsume, 1976).

Four stages of the disease were identified: latent, visceral, manifest, and delayed. The latent stage was asymptomatic in the adult, but PCB entered the tissues and, in lactating mothers, was transferred to nursing infants via the milk. Dark pigmentation of the infants' nail beds and mucus membranes of the eyes were signs of latent contamination.

In the visceral stage, victims experienced nausea, vomiting, and weak to mild jaundice with coughing and bronchitis. The manifest stage was characterized by dermatological signs with dark pigmentation of skin and nails, runny eyes, hair loss, numbness of extremities, dizziness, and some long-range chronic effects.

In the delayed or tardy stage, the pathologic signs and symptoms remained latent for up to 3 years following the rice oil incident.

As awareness of the Japanese episode spread through the medical and scientific community, PCB's were identified as cosmopolitan contaminants in air, water, animal, and human tissues, where they show an affinity for and accumulate in fats.

PCB Control

During the intervening years, Federal and State legislation has increasingly restricted the use of PCB's with the objective being ultimate elimination. Their use in other than limited closed systems (capacitors and transformers) is presently banned and disposal of existing PCB stocks is closely regulated by Federal and State laws. PCB levels in terrestrial, aquatic, and marine ecosystems and their biota are being monitored routinely by State and Federal agencies.

Maryland's Department of Health and Mental Hygiene includes PCB analyses among an array of parameters assayed in finfish and shellfish from the Chesapeake Bay, the Nation's largest and most productive estuary. The State of New York has a comparable program for monitoring PCB's in the Hudson River watershed and estuary (Hetling et al., 1978).

Filter-feeding bivalve mollusks are efficient concentrators of most particulate and some dissolved pollutants and heavy metals and they are sometimes employed as indicator species. Monitoring shellfish serves both to determine their safety and wholesomeness as food and to evaluate the condition of their aquatic environment.

Materials and Methods

The Maryland Department of Health and Mental Hygiene continually monitors the edible fishes of the Chesapeake Bay and its tributaries for heavy metals, chlorinated hydrocarbons, and other physical and biological parameters (Fig. 2). During 1976 approximately 300 samples of finfish and shellfish collected from 100 stations in Maryland's portion of the Chesapeake Bay and its tributaries were analyzed for PCB's. Shellfish were collected by tongs or dredges while finfish were taken by trawls, gill nets, or hook-and-line. Occasionally, samples were obtained on station from commercial fishermen. Mollusks were sampled on a year-round basis, and finfish were sampled as they were seasonally available.

One hundred thirty-one samples of mollusks (principally American oyster, *Crassostrea virginica*) and 146 samples of finfish—principally bluefish, *Pomatomus saltatrix*; striped bass, *Morone saxatilis*; white perch, *Morone americana*; and weakfish, *Cynoscion regalis*—were included in the study. All samples were analyzed for pesticides and heavy metals. Several miscellaneous shellfish and finfish were also analyzed, including roe samples of gravid striped bass, white perch, and yellow perch, *Perca flavescens*, and the meat of three blue crabs, *Callinectes sapidus*.

For pesticide and PCB analyses, finfish were gutted and filleted and the fillets used for extraction. Mollusks were scrubbed clean, shucked and drained, and the shell liquor discarded. In both cases approximately 200 g of meat were homogenized. For finfish 50-g and for shellfish 100-g portions of homogenate were utilized. Analytical procedures were in accordance with the U.S. Food and Drug Administration (FDA) procedures (McMahon and Sawyer, 1977). Homogenates were extracted with acetonitril. The acetonitrile extracts were diluted with water, the residues transferred to petroleum ether, and the ether put through a Florisil column[2] to separate the residues from the other extracted substances. Hexane was used as the first eluant to separate the PCB's from most of the other chlorinated hydrocarbons. The eluate

[2]10 percent DC 200 on Chromosorb WHP, 80/100 mesh; column temperature 190°C.

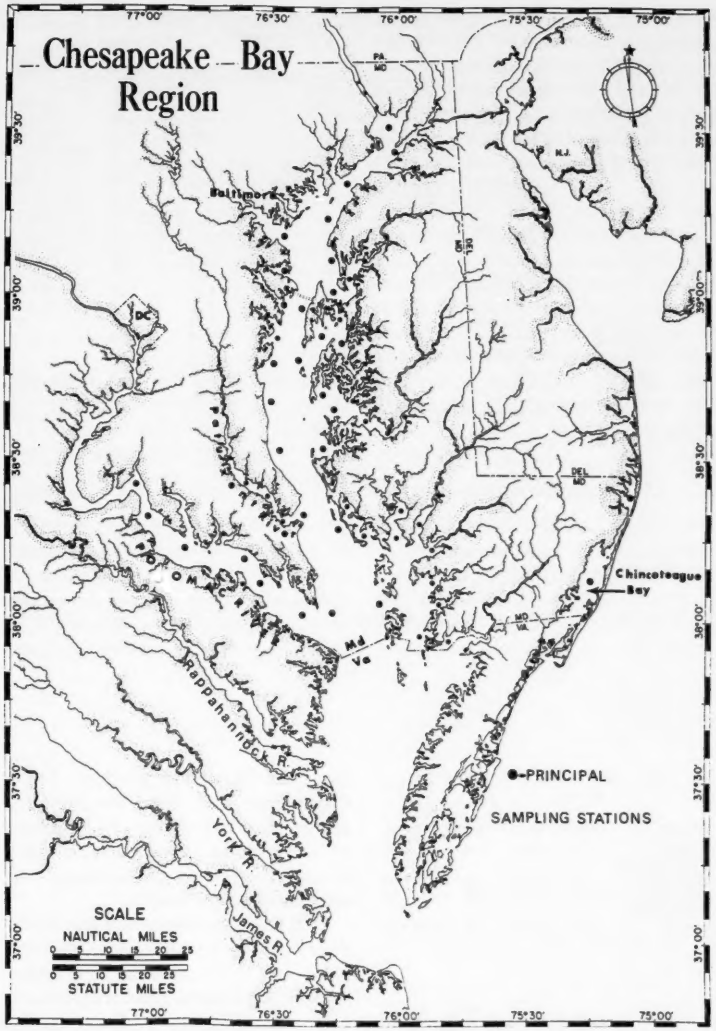

Figure 2.—Chesapeake Bay showing principal sampling stations.

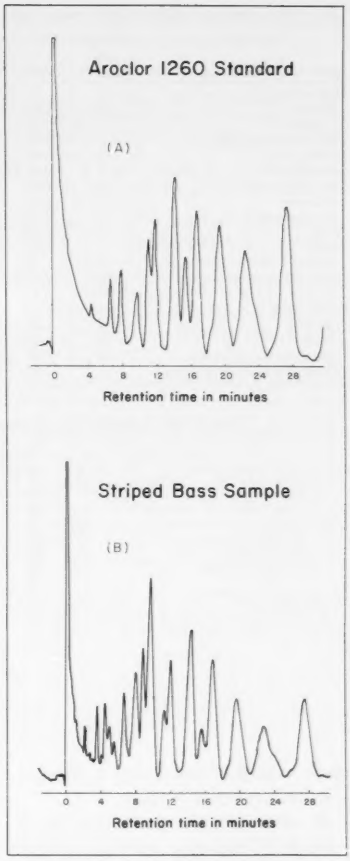

Figure 3.—Gas chromatograms of standard Aroclor 1260 (A), and of striped bass sample (B). Gas chromatography was performed on a Barber Coleman 5360 chromatograph with 10 percent DC on Chromosorb WHP (80/100 mesh) and electron capture detector (^{63}Ni). The injection temperature was 250°C and the column temperature was 230°C.

was concentrated and the residues identified and quantitated on Perkin Elmer Models 900 and 3920 and Barber Colman Model 5360 gas chromatographs equipped with ^{63}Ni detectors. Retention time of peaks in the standard were matched against peaks in the sample (Fig. 3) and concentrations were calculated from height of matching peaks.

Results

Finfish results for both PCB 1254 and 1260 are summarized in Table 1 and for shellfish in Table 2[3]. Combined results are listed in Table 3. In 80 finfish samples the level of PCB 1254 averaged 0.20 ppm while in 66 samples PCB 1260 showed an average concentration of 0.34 ppm. The weighted PCB's average for 146 samples tested was slightly less than 0.27 ppm, with a range of 0 to 0.98 ppm. Striped bass averaged 0.23 ppm, bluefish about 0.35

[3]Detection limits are valid to parts per billion (ppb).

Table 1.—Maryland PCB survey of finfish, 1976.

Species and PCB	Number of samples	PCB levels (ppm) Mean	Median	Range
Finfish (1254)				
Rockfish	44	0.23	0.18	0 to 0.58
Bluefish	2	0.32	0.32	0.31 to 0.33
Seatrout (weakfish)	12	0.05	0.05	0.02 to 0.13
White perch	13	0.21	0.24	0 to 0.42
Yellow perch	3	0.20	0.18	0.13 to 0.29
Pumpkinseed	1	0.35	0.35	
Mehaden	1	0.49	0.49	
Channel catfish	1	0.43	0.43	
Carp	1	0.12	0.12	
Spot	1	0.07	0.07	
Flounder	1	0	0	
(1254) Averages and range	80	0.20	0.16	0 to 0.58
Finfish (1260)				
Rockfish	4	0.24	0.25	0.22 to 0.26
Bluefish	62	0.35	0.32	0.04 to 0.98
(1260) Averages and range	66	0.34	0.31	0.04 to 0.98
(Both PCB's) Averages and range		0.27	0.23	0 to 0.98

Table 2.—Maryland PCB survey of shellfish, 1976.

Species and PCB	Number of samples	PCB levels (ppm) Mean	Median	Range
Shellfish (1254)				
Oysters	115	0.02	0.03	0 to 0.07
Hard Clams	3	0.02	0.02	0 to 0.03
Softshell clams	13	0.02	0.03	0 to 0.06
Averages and range	131	0.02	0.03	0 to 0.07
Shellfish (1260)				
Blue crabs	3	0.05	0.05	0.04 to 0.05

Table 3.—Maryland PCB survey of shellfish and finfish, 1976.

Species and PCB	Number of samples	PCB levels (ppm) Mean	Median	Range
Shellfish (1254)				
Oysters	115	0.02	0.03	0 to 0.07
Hard clams	3	0.02	0.02	0 to 0.03
Softshell clams	13	0.02	0.03	0 to 0.06
Shellfish (1260)				
Blue crabs	3	0.05	0.05	0.04 to 0.05
Shellfish (1254 & 1260) average & range	134	0.02	0.03	0.00 to 0.07
Finfish (1254)				
Rockfish	44	0.23	0.18	0 to 0.58
Bluefish	2	0.32	0.32	0.31 to 0.32
Seatrout (weakfish)	12	0.05	0.05	0.02 to 0.13
White perch	13	0.21	0.24	0 to 0.42
Yellow perch	3	0.20	0.18	0.13 to 0.29
Pumpkinseed	1	0.35	0.35	0.35
Mehaden	1	0.49	0.49	0.48
Channel catfish	1	0.43	0.43	0.43
Carp	1	0.07	0.07	0.07
Spot	1	0.07	0.07	0.07
Flounder	1	0.00	0.00	0.00
Finfish (1254) average & range	80	0.02	0.16	0.00 to 0.58
Finfish (1260)				
Rockfish	4	0.24	0.25	0.22 to 0.26
Bluefish	62	0.35	0.32	0.04 to 0.98
Finfish (1260) average & range	66	0.34	0.31	0.04 to 0.98
Finfish (1254 & 1260) average & range	146	0.26	0.26	0.00 to 0.98
Finfish roe (1260)				
Rockfish	1	2.20	2.20	
White perch	1	0.33	0.33	
Yellow perch	2	2.55	2.55	1.77 to 3.33
Finfish roe (1260) average & range	4	1.90	1.98	0.33 to 3.33

ppm, weakfish (sea trout) 0.50 ppm, and white perch 0.21 ppm.

Bivalve mollusks had almost negligible PCB burdens, showing a mean level of 0.02 ppm in 131 samples. Oysters, the most important food resource in the Chesapeake Bay, ranged from 0 to 0.07, with an average 0.02 ppm of PCB 1254. Softshell clams, *Mya arenaria*, showed mean and median levels identical to oysters. Three blue crab, *C. sapidus*, samples tested for PCB 1260 also gave low readings with mean and median levels of 0.05 ppm. With both finfish and shellfish, no area tested in Maryland waters showed marked PCB increases above the mean or median.

Four incidental samples of fish roe were included in the study. This was insufficient to constitute a representative sample, but possibly adequate to indicate a trend (Table 4). As expected, the gametes showed appreciably elevated PCB (1260) levels as compared with somatic tissues, averaging 1.9 ppm with a range of 0.33 to 3.33. White perch roe averaged 0.33 ppm while striped bass and yellow perch averaged 2.20 and 2.55 ppm, respectively.

Table 4.—PCB (1260) content of finfish roe.

Species	Number of samples	PCB levels (ppm) Mean	Median	Range
Rockfish (striped bass)	1	2.20	2.20	2.20
White perch	1	0.33	0.33	0.33
Yellow perch	2	2.55	2.55	1.77-3.33
Average and range	4	1.90	1.98	0.33-3.33

Discussion

The PCB values of finfish in our study averaged approximately 0.26 ppm, well below the present FDA limit of 5 ppm and an order of magnitude below the proposed 2 ppm standard. In 1976, Westinghouse Electric Corporation conducted a study of PCB's in the Chesapeake Bay for the Environmental Protection Agency (Munson et al., 1976). In 27 samples of striped bass from the Maryland portion of the Chesapeake Bay, the Westinghouse study showed an average PCB burden of 0.26 ppm, an almost identical value to our findings with approximately 140 samples of mixed species.

PCB levels in Chesapeake Bay fishes determined by the Annapolis Laboratory of the Environmental Protection Agency were also in general agreement with ours (Forns[4,5]). Conversely, findings by New York State's ongoing PCB monitoring program indicated levels in New York's freshwater and estuarine finfishes substantially higher

[4]Forns, J. M. 1975. Marine biology. *In* T. O. Munson, D. K. Fla, and C. Rutledge (editors), Upper bay survey, final report to the Maryland Department of Natural Resources, II, p. 1-35. Westinghouse Ocean Research Laboratory, Annapolis, Md.

[5]Forns, J. M. 1976. PCB concentrations in striped bass and eggs. Final report to EPA, No. WD6-99-0673B, 10 p. Westinghouse Ocean Research Laboratory, Annapolis, Md.

Table 5.—PCB levels in selected New York finfish, 1977.[1]

Location	Species	No. of samples	Average PCB levels (ppm)
Lake Ontario	Smallmouth bass	297	4.02
	Trout	20	5.30
	White perch	81	4.11
St. Lawrence River	Smallmouth bass	46	2.20
	White perch	14	5.00
Hudson River	Striped bass	116	13.85

[1]Derived from: New York State Department of Environmental Conservation, 1977. Monthly report on toxic substances impacting on fish. Division of Fish and Wildlife Report I, April 20, 1977, 14 p.

than some we have found (Hetling et al., 1978; Table 5). Munson et al. (1976) found that Virginia samples were generally higher than those from the Maryland portion of Chesapeake Bay.

The PCB in bivalve mollusks was predominantly compound 1254 and in the decapod crustacean blue crabs it was mainly formula 1260. In the finfish 1254 was also predominant, except for bluefish, where 1260 again prevailed (Tables 1-3). Munson et al. (1976) found PCB 1254 predominant in Maryland fishes while 1260 predominated in the Virginia portion of the Bay. However, regardless of geographic origin, the predominant PCB in finfish roe was 1260, again in accordance with our findings (Table 4).

The current FDA tolerance or "action level" for PCB's in foodfish is 5 ppm. Barring drastic, unanticipated increases in concentrations, PCB's in edible fishes from the Chesapeake Bay should remain far below existing or proposed maximum permissible levels. Preliminary findings from our 1978 Chesapeake Bay Survey show no significant variations for the results reported here.

Acknowledgments

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Munson, T. O., H. D. Palmer, and J. M. Forns. 1976. Transport of chlorinated hydrocarbons in the upper Chesapeake Bay. *In* Proceedings of the national conference on polychlorinated biphenyls, 1975, EPA-560/6-75-004, p. 218-229. U.S. Environ. Prot. Agency, Wash., D.C.

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Bait Loss From Halibut Longline Gear Observed From a Submersible

WILLIAM L. HIGH

Introduction

Demersal longline gear is fished along the west coast of the United States for Pacific halibut, *Hippoglossus stenolepis*; sablefish, *Anoplopoma fimbria*; and spiny dogfish *Squalus acanthias*. Little information is available on the behavior of fish around the gear and bait, bait durability on hooks, predators other than the target species, and other factors. Usually the gear is fished in deep water, quite inaccessible to direct view or remote data collecting systems. Consequently most conclusions drawn as to catch per unit effort, bait or hook effectiveness, predation on bait and catch, and competition by various species are derived after the gear is retrieved.

Skud and Hamley (1978) reported upon experiments conducted by the International Pacific Halibut Commission (IPHC) to measure catch with relation to soak (time left on the bottom) and bait loss. They reported that bait loss occurred while the gear was being set and from feeding by target species and by other predators.

ABSTRACT—During July 1978 the submersible Nekton Gamma *was used by National Oceanic and Atmospheric Administration (NOAA) investigators to observe halibut longline gear in Alaskan waters. Rate of Pacific herring,* Clupea harengus pallasi, *bait loss to predators was higher than of octopus,* Octopus dofleini, *baited hooks. Species of fish caught included Pacific halibut,* Hippoglossus stenolepis; *arrowtooth flounder,* Atheresthes stomias; *sculpins, family Cottidae; rockfishes, family Scorpaenidae; and others.*

During July 1978 National Oceanic and Atmospheric Administration (NOAA) scientists conducted a series of dives using the chartered submersible *Nekton Gamma* to study longline gear and predation on bait. The study was conducted in Frederick Sound, Alaska, adjacent to the northwest shore of Kupreanof Island. Our objective was to view from the *Nekton Gamma* demersal halibut longline gear on commercial fishing grounds. When we were near the bottom, we observed 1) the behavior of fish before, during, and after they attacked the bait on the hooks, 2) other predators of the bait, and 3) length of time the bait, either Pacific herring, *Clupea harengus pallasi*, or octopus, *Octopus dofleini*, remained on the hooks.

Methods

Two typical halibut longline skates, composed of 250-fathom (fm) (458-m) groundline with 13-foot (4.0-m) hook spacing (IPHC, 1978) were fished from the NOAA RV *John N. Cobb* at depths from 165 feet (50.3 m) to 540 feet (164.6 m). The gear was set slowly without a chute to reduce the possible loss of bait from hooks during the set. The skates were baited with large herring pieces (from frozen blocks) except for one skate having herring and fresh octopus pieces on alternate hooks.

Following the set, the *John N. Cobb* stood by to assist the *Nekton Gamma* if it became entangled with the halibut longline gear. A self-contained battery-powered acoustic transmitter was attached near the gear anchor for the submersible pilot to locate the groundline. While the pilot maintained a course parallel to the groundline and, when possible, 2-3 feet (0.6-0.9 m) off bottom, we attempted to view each hook. Observations, voice recorded on magnetic tape, included presence or absence of bait on hooks, predators present or eating the bait, fish species hooked or near the bait, and whether the hook was fishing or snagged. We photographed the gear, predators, and fish with an externally mounted 35-mm underwater camera.

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Results

Four dives were made to view the sea floor and longline gear. The sea floor composition varied from gravel to boulders rising 5-6 feet (1.5-1.8 m) off bottom and equally long. The large boulders presented some hazard to the submersible, especially when it was necessary to travel down current. Unfortunately, the current on the bottom could not be predicted from the direction or magnitude of the surface current.

We were able to view the longline gear and fish readily from the submersible. Fish did not appear frightened during these or other survey dives. On the contrary, halibut followed us several times until we could count as many as 15 (Fig. 1). Halibut dispersed slowly after the submersible settled to the sea floor, whereas sculpins occasionally gathered in moderate numbers (well over 50 individuals) while we were motionless.

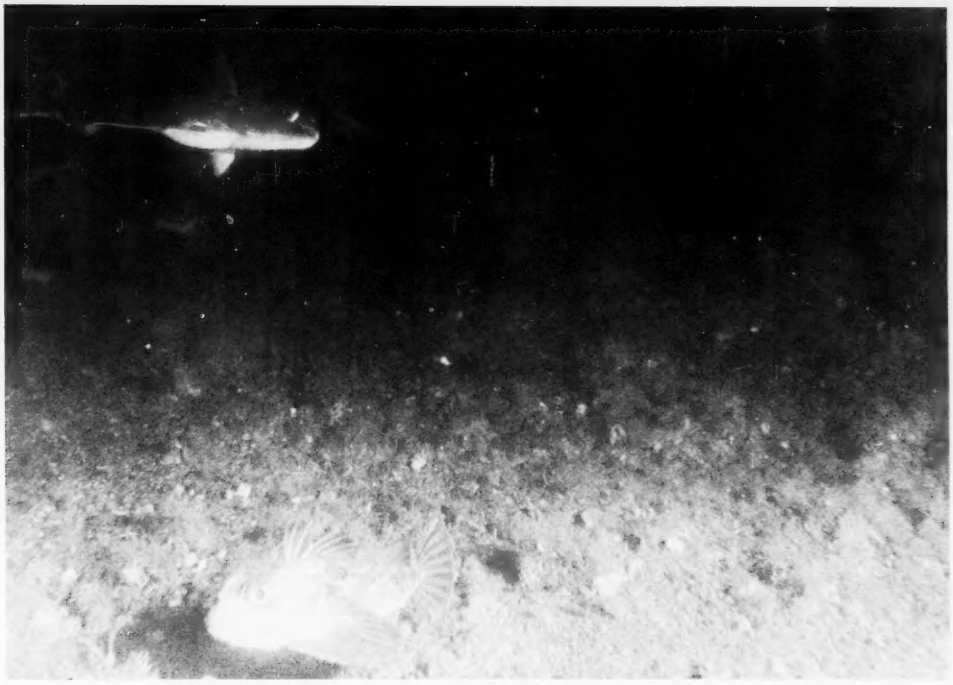

Figure 1.—Both halibut and sculpin were attracted to the submersible. Note swimming halibut in the upper left with two others nearly obscured behind it.

Bait Loss

Strong tidal current on the bottom precluded our prompt arrival at the gear site to observe whether the setting process contributed to bait loss. Consequently our first view of the hooks was 30 minutes or more after the set. Even after this short period, crab and shrimp were actively feeding on the baited hooks. Because the International Pacific Halibut Commission studies showed that few baits were lost to the normal setting process and our gear sets were carefully done to avoid bait loss, we concluded that all observed bait loss was from predators (Fig. 2). The observed gross bait loss rate exceeded a 50 percent loss within 5 hours reported by Skud and Hamley (1978). Hooks with fish were excluded from the tabulation.

Figure 2.—Loss of herring and octopus bait from longline hooks in relation to length of time after the gear had been set.

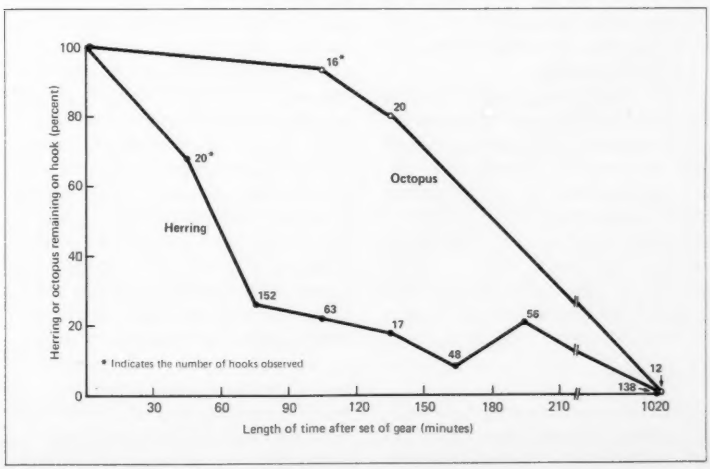

Figure 3.—A portion of demersal longline with a gangion and hook is shown on the sea floor. Two shrimp of the type seen covering many baits were apparently attracted to the bait.

While one could reasonably assume that bait was available when the fish became hooked, our observations showed that eight fish were hooked at locations where previously the hook was without bait. We offer no explanation for this anomaly.

Shrimp, hermit crab, and brachyuran (true) crab were the most abundant observed predators on herring-baited hooks in Frederick Sound (Fig. 3). Often we could not see the herring bait beneath a mound of feeding animals.

Octopus baits, on the other hand, only once appeared to have an animal feeding on them. Our observations suggested that herring, though fragile, was more attractive to predators.

Fish Catches

Some fish passed near the baits without apparent interest while other fish were seen to strike at the bait or become hooked. Of 56 fish we observed hooked during the several dives, 14 (25 percent) were missing from the gear on the subsequent survey. Six of 10 (60 percent) arrowtooth flounder, *Atheresthes stomias*, were missing, whereas only 5 of 26 (19 percent) Pacific halibut were missing. We thought these fish escaped or were removed by larger predators. A large skate, *Raja binoculata*, became hooked where we previously observed an arrowtooth flounder. Other species observed hooked included sculpin, family Cottidae; yelloweye rockfish, *Sebastes ruberrimus*; Pacific cod, *Gadus macrocephalus*; salmon shark, *Lamna ditropis*; and shortspine thornyhead rockfish, *Sebastolobus alascanus*.

The catch of fish on herring-baited hooks increased in a decreasing rate with soak during the first 3 hours until most herring bait was gone from the hooks (Fig. 4). Octopus, on the other hand, produced few fish caught during the early soak. While we recognize that the data are meager, it does suggest that the catch rate of hooks with octopus bait is low. Octopus bait was apparently less attractive to small feeding invertebrates, and because the flesh is tough, the bait remained on the hooks over a long period resulting in a catch similar to that with herring bait. Therefore, when halibut longline gear must have a long soak, octopus bait will remain available for a longer time than herring. When the gear soak is short, octopus offers no advantage.

Some hooked fish were detected at a distance greater than 65 feet (19.8 m) because their escape efforts caused considerable movement of the groundline. On one occasion, a hooked halibut swam more than 8 feet (2.4 m) off bottom carrying the groundline onto our submersible. Deft maneuvering

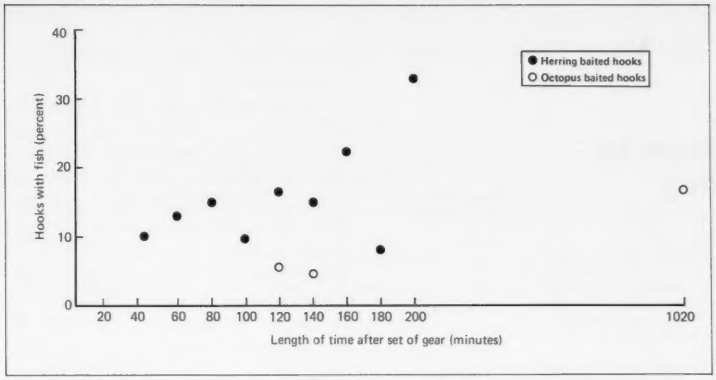

Figure 4.—Catch of fish on herring- or octopus-baited hooks at time intervals following gear set.

cleared the line but the incident pointed up a potential hazard to a submersible operating near gear considered to be lying quietly on the ground.

Summary

Our observations of longline halibut hooks in Frederick Sound, Alaska, baited with Pacific herring or octopus, show that predators such as fish, shrimp, hermit crab, and brachyuran crab contribute to a rapid loss of herring bait. Herring bait attracted far greater numbers of invertebrates than did fresh octopus and, as a result, after a 2-hour soak, more than 80 percent of the herring was consumed whereas only about 15 percent of the octopus was missing from the hooks. Catch of fish on herring-baited hooks in the first 2 hours of soak was much higher than for octopus-baited hooks. A decreasing catch rate for herring with soak is associated with the rapid bait loss. Although the data are meager, they suggest that because of the longer retention of octopus bait on the hook, the catch in long soaks is similar to that of herring. Therefore, on grounds with many actively feeding invertebrates, fishermen are faced with the selection of a best balance of bait type and length of soak.

Strong near-bottom currents and unpredictable movements of the groundline caused by hooked fish presented some potential hazards to the submersible.

Acknowledgments

These observations made by the author, Lou Barr (NMFS Northwest and Alaska Fisheries Center, Auke Bay Laboratory), and submersible pilots, Rick Olsen and Rex Horton, were made possible by the combined efforts of all members of the Project Sea Sub research team. The team included Captain Larson, Field Party Chief Robert Loghry, and crew of the NOAA RV *John N. Cobb*, the crew of the submersible *Nekton Gamma*, and Captain Jeff Hendricks and his crew aboard the chartered vessel *Antares*. The submersible charter was provided by the NOAA Manned Undersea Science and Technology Office.

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Three Different Delivery Modes for Fresh-Caught Pacific Whiting, *Merluccius productus*

CAVIN W. PHILBIN

Introduction

The objective of this paper is to aid American fishermen in making decisions on whether to enter into the Pacific whiting, *Merluccius productus*, fishery and to illustrate three possible modes of delivery. It is not the intention of this report to promote a particular approach but to create an unbiased view to put forth as many feasible options as possible to the potential Pacific whiting fisherman.

Costs and fishing periods mentioned in this paper are conservative. However, it must be remembered that the catch rates illustrated were recently achieved by a very modern and efficient trawler, designed for the purpose of catching a high volume species such as Pacific whiting, by a highly competent skipper and crew.

It should be stressed that this paper deals only with the nature of the Pacific whiting fishery at present and that persons concerned should realize that a continuing investigation of this fishery is needed as technology and effort increase. To avoid some of the problems that have characterized domestic fisheries in the past, management, business, and education should work together to guarantee that the Pacific whiting fishery sustain itself to as many people and for as long as possible.

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When the U.S. Congress provided the American fisherman with the 200-mile fishing zone, the United States became trustee of a valuable source of national income as well as a potential reserve of world protein. As a nation, we are responsible for its efficient utilization.

Pacific whiting is one of the most abundant species of fish in the northeast Pacific Ocean. During the months of April through November, long, narrow, dense schools of Pacific whiting migrate from waters off southern California to Oregon and as far north as Vancouver Island, Canada (Nelson and Larkins, 1970).

Pacific whiting are generally caught at depths that range from 20 to 200 fathoms. According to reports from a 1978 U.S. observer, large foreign trawlers set nets at depths usually between 100 and 150 fathoms while smaller American fishing boats concentrate their effort between 60 and 100 fathoms, using mid-water trawl gear. This species is harvested primarily during the day due to its rise and dispersion in the water column at night to feed (Nelson and Larkins, 1970).

In April 1966, the Soviets began an intensive trawl fishery for Pacific whiting off the coasts of Oregon and Washington, landing an estimated 141,000 tons. During the latter part of the 1960's and early 1970's, the Soviet fleet alternated fishing effort off the Oregon and Washington coasts. During April, May, August, and September, the Soviets fished primarily off the Oregon coasts while during June, July, October, and November, the Soviet fishing effort remained mostly off Washington (Hitz, 1970).

The general feeling from fishermen and government officials alike is that schools of Pacific whiting are now concentrated primarily off the coast of Oregon, between Coos Bay and Astoria. Part of this change of distribution pattern is due to the establishment of closed areas off the Washington coast and changes in the age composition of the stocks. According to Bill Neff of Pacific Hake Fisheries of Astoria, Oreg., most of the resource tends to congregate between Coos Bay and Newport, Oreg., from May to July. As August approaches the schools begin migrating northward, centering primarily off Astoria. A large percentage of the catch has occurred roughly 20-30 miles off Heceta Head, about a 6-hour run north of Coos Bay.

From an optimum yield for Pacific whiting of 130,000 metric tons (t), the domestic annual harvest (DAH) was established for 1978 at 41,000 t by the Preliminary Management Plan for the trawl fisheries of Washington, Oregon, and California.[1] The DAH for this species was established by surveying domestic processors concerning projections of their 1978 processing capabilities for Pacific whiting. Marine Resources Co.[2] projection of its processing intentions for Pacific whiting in 1978 was 34,000 t, or all but 7,000 t of the total DAH. Marine Resources Co. is a U.S. corporation which has succeeded in negotiating the lease of Russian processor vessels in order to process American-caught Pacific whiting off the coasts of Washington and Oregon.

In September of 1978, the trawler *Lady of Good Voyage* was one of two trawlers contracted by Marine Resources Co. to deliver Pacific whiting to the Russian BMRT trawler/processor,

[1]Stafne, S. E. 1978. White paper on the permit applications for the Sulak and Tikvin to process fish for Marine Resources Company, Inc., a U.S. company. Unpubl. manuscr., 104 p. Stafne and Hemphill, Seattle, Wash.

[2]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Table 1.—Delivery mode comparison and vessel characteristics.[1]

Item		Description		
(1)	Vessel, *Lady of Good Voyage*			
	(a) Two diesel engines: 365 hp each, 730 hp/1800 rpm			
	(b) Fishing gear: Polish rope wing trawl for midwater trawling			
	(c) Generating capacity: 150 kw			
	(d) Gearing: 5.1/7.1 reduction gear; kort nozzle; two propellers			
	(e) Hold capacity: 280,000 pounds iced; 5,300 cubic feet.			
	(f) Heading and gutting machine: Baader model 160, 35 to 45 fish per minute			
	(g) Chilled seawater system used for fishing mode delivering round Pacific whiting to shore-based processor			
(2)	Mode	A	B	C
		Round delivery to shore plant	Headed and gutted delivery to shore plant	Delivery to floating processor
(3)	Crew	6 (5 working)	7 (6 working)	5 (4 working)
(4)	Operating schedules[2]	20 days fishing/month 20 days down for adverse weather & processing complications 100 total annual fishing days	20.5 days fishing/month 20 days down for adverse weather and processing complications 103 total annual fishing days	24 days fishing/month 11 days down for adverse weather 133 total annual fishing days
(5)	Daily catch in weight delivered	42 tons/day	34.65 tons/day @ 60% yield = 20.79 tons/day	42 tons/day
(6)	Annual catch rate	4,200 tons/season	2,141.37 tons/season	5,628 tons/season
(7)	Ex-vessel price	0.06¢/pound ($132.00/ton)	0.15¢/pound ($300.00/ton)	0.06¢/pound ($132.00/ton)
(8)	Gross stock	$554,400.00	$642,411.00	$742,896.00
Operating Expenses; Expendables				
(9)	Fuel	$19,008.00	$18,981.00	$17,334.00
(10)	Provisions	$6,600.00	$7,931.00	$7,370.00
(11)	Ice	$23,650.00	$9,477.20	no ice needed
(12)	Lubrication etc.	$6,000.00	$6,000.00	$6,000.00
	Subtotal	$55,258.00	$42,389.20	$30,704.00
(13)	5% Contingency	$2,762.90	$2,119.46	$1,535.20
(14)	Oregon state landing tax	$21,000.00	$10,706.85	not applicable
Total operating expenses		$79,020.90	$55,215.51	$32,239.20
(15)	Gross profit for division	$475,379.10	$587,195.49	$710,656.80
(16)	Crew share (35%)	$166,382.68	$205,518.42	$248,729.88
	each crew share	$27,730.45 (5.8%)	$29,359.77 (5.0%)	$49,745.98 (7.0%)
(17)	Captain's share (15%)	$71,306.87	$88,079.32	$106,598.52
(18)	Gross vessel share (50%)	$237,689.55	$293,597.74	$355,328.40
Fixed annual costs				
(19)	Gear maintenance	$15,000.00	$15,000.00	$15,000.00
(20)	Hull insurance	$15,750.00	$15,750.00	$15,750.00
(21)	P & I	$12,500.00	$15,000.00	$10,000.00
(22)	Depreciation	$99,526.96	$99,526.96	$99,526.96
(23)	Business and indebtness	$75,000.00	$75,000.00	$75,000.00
	Total fixed costs	$217,776.96	$220,276.96	$215,276.96
	Profit before taxes	$19,912.59	$73,320.78	$140,051.44
(24)	Income tax	$3,989.52	$16,563.40	$33,913.37
Net profit		$15,930.07	$56,757.38	$106,138.07

[1]Table based on: Jaeger, S. 1977. Presentation to the North Pacific Fisheries Management Council on the subject of foreign joint ventures. Unpubl. manuscr., 28 p. North Pacific Fishing Vessel Owners Association, Seattle, Wash.
[2]Pacific whiting fishing season, 1 May through 31 October.

the *18th Congress*. The catch was transfered to the Soviets by detaching the "cod-end" with the fish.

This historic event occured after an amendment to the Fisheries Conservation and Management Act of 1977, an act which initially provided U.S. fishermen with preemptive access to all waters within 200 miles of the U.S. coast. The amendment to this act, passed in August 1978, gave U.S. processors first option to process fish within this zone. Until domestic processors develop the capabilities needed to process this vast biomass, foreign processors are allowed to enter and offer their processing vessels as markets to U.S. fishermen. Whether it be a domestic or foreign processor, the U.S. fisherman is now guaranteed a market in which to sell his fish.

Vessel Characteristics (1)[3]

The *Lady of Good Voyage* is an 86-foot by 26-foot steel stern ramp trawler, designed to fish for high volume, low unit value species of fish, like Pacific whiting, that inhabit waters in close proximity to port. Other vessel characteristics are listed in Table 1. In this paper, this vessel is used as a hypothetical model to exhibit various processing capabilities, methods of icing fish, and fishing strategies, depending on the mode of fishing.

[3]Numbers in parentheses refer to item listing in Table 1.

Delivery Modes (2)

Three different modes of fishing, A, B, and C, are discussed in this paper. Mode A entails delivering fresh-caught Pacific whiting in the round to a shore-based plant located within about 60 miles from the fishing grounds. The product would be quick chilled immediately after bringing it on board. Chilled seawater is the method used in this mode for chilling.

Mode B entails delivering fresh-caught headed and gutted whiting to a shore-based plant located within 60 miles of the fishing grounds. Heading and gutting of the fish would be done on board the fishing vessel as soon after catching as possible. The product would be packed in ice provided by the shore-based plant.

In Mode C fresh-caught whiting would be delivered in the detachable "cod-end" portion of the net to an ocean-based processor variably located on the fishing grounds.

Due to the nature of this vessel and the scope of this paper, filleting Pacific whiting on board ship has not been mentioned. A filleting operation requires from 12 to 15 men and a vessel well over 100 feet in length.

Delivery Modes (2)

The three different fish delivery modes chosen assume that a school of whiting is located about 6 hours running time from the main port. The purpose of choosing these three modes of delivery revolve around the question concerning the time it takes Pacific whiting to spoil.

Pacific whiting migrating along the west coast of the United States contain a high incidence of microscopic myxosporidian parasites (*Kudoa* sp.) in their flesh. Pacific whiting containing these parasites in moderate amounts have a serious proteolysis of the tissue, reducing the edible portions of the product to a mushy unpalatable consistency shortly after it is hauled on board (Dassow et al., 1970).

The main variables which determine its deterioration are heat, the quality of shipboard handling, the amount of time before the fish is refrigerated or processed, and the degree of parasite incidence. According to Tom Dark of the National Marine Fisheries Service (pers. commun.), the amount of time it takes this fish to become unfit for human consumption without refrigeration is about 4 hours on deck. Personnel involved with handling whiting catch aboard the Soviet processing vessel state that the fish must be processed within 2 hours to make an acceptable food-grade quality product. Wally Welch (pers. commun.), a veteran Pacific whiting fisherman from Astoria, Oreg., insists that after 1 hour in the ocean, the catch is fit only for fish meal.

Logistically, a fisherman is left with three options. An alternative that has met with considerable success, mode C, is to simply tow the catch to a nearby processing vessel, "unzipper" the detachable cod-end portion of the net and transfer it by some means to the ramp of the processing vessel.

An early method of transfer involved having a Russian BMRT drop a line off the stern ramp with a buoy attached. The trawler, after bringing in the catch, would attach the cod-end to the line and the Russian vessel would haul the catch aboard for processing.

A much more efficient method now being used involves simply tieing a buoy to the cod-end after the trawler brings in the catch and radioing the factory ship to collect the tow. The efficiency of this delivery mode is furthered by allowing the fishing vessel a maximum amount of time to trawl and stay on the main school of fish.

A second delivery alternative for the Pacific whiting fisherman is to haul the catch aboard his own vessel and quick-chill the product in either chilled or refrigerated seawater. With adequate ice storage, a fisherman could readily adapt a chilled seawater system into the hull of his vessel.

There are limitations to this mode of delivery, however. It appears that with the present state of the art, Pacific whiting kept in chilled seawater remains at an acceptable marketable quality for up to 3 days (Dassow et al., 1970). Because the quality rapidly deteriorates after this time, a 2 day maximum would be the limit for mode A.

A third alternative for a fisherman is to upgrade the product before delivery, such as in mode B. By installing a heading and gutting machine on board the fishing vessel, a fisherman can haul his catch aboard, head and gut the product, and pack it in ice. This would increase the price of the raw material by roughly 250 percent. (The 1978 price paid for headed and gutted Pacific whiting from Pacific Hake Fisheries, Astoria, Oreg., was 15 cents/pound.) Headed and gutted Pacific whiting, if handled properly, will retain good quality up to 3 days.

Crew (3)

In each of these fishing modes, the work load expected of the crew is considerable; therefore, rotating the crew members would be a desirable means of increasing vessel production while allowing each of the crew a break in the action. Having an extra crew member assures the vessel an adequate crew in case of sickness or accident, increases the efficiency of a vessel, and allows enough rest for each crew member to secure a safe working environment on board.

The four working crew members on board fishing mode C, with the trawler delivering to a floating processor, are adequate to handle the fishing, gear handling, and product transfer. According to Barry Fisher, skipper of the *Lady of Good Voyage*, with increased fishing and technological efficiency in the future, three working crew members could very well be adequate for this fishing mode (pers. commun.).

Since fish hauled aboard the trawler using fishing mode B would have to be split and sorted on deck, this trawler would require four crew members handling the gear while two crew members operated the heading and gutting machine. Crew members would have to alternate between handling the gear and icing the finished product; therefore six crew members would be needed for fishing mode B.

Five crew members would be sufficient in mode A to handle the gear, ice the raw product in chilled seawater, and run it to a shore based facility.

Operating Schedules (4)

This paper uses a focal point 20 miles off Heceta Head as the location of the fishing grounds, and Coos Bay as the respective home port for shore-based facilities. This point was arrived at by investigating previous accounts of Russian trawler activity off the Coast of Oregon in 1966 and 1967 (Hitz, 1970), in addition to using the area where most activity took place during the 1978 Pacific whiting season. Within this

general area, a trawler has about 20-60 miles to cruise between port and the fishing grounds. An approximate maximum cruising time can be listed here as 6 hours, if average cruising speed is 10 knots.

A trawler with mode C's intentions is benefited with a more flexible operating schedule than a vessel delivering the product to shore. If the vessel encounters favorable fishing conditions, time at sea could be extended much more than if the vessel were limited with product delivery limitations encountered by modes A and B. The only necessary tasks that would be performed in port by mode C would be refueling, picking up groceries, and rotating the crew.

Fishing schedules vary tremendously within the inherent flexibility found in mode C. One Pacific whiting fisherman projects a rather demanding schedule of rotating an entire crew after 7 days of steady trawling. This projection recognizes no down time whatsoever. Another less strenuous schedule suggests fishing for 5 days interrupted by 2 days of down time.

Based on these projections, a practical fishing schedule for mode C can be listed at 8 days fishing followed by 2 days in port. This represents a maximum of 24 fishing days a month, or at best, 144 fishing days annually. Off the coast of Oregon, however, a fisherman can expect to confront weather complications that often force a vessel to stay in port a few days. Rough seas are compounded by the effect of shallow river bars, making passage unsafe. Barry Fisher, a veteran fisherman to the Oregon coast, expects a total of 11 days of adverse weather to prevent fishing and delivering to a floating processor. The majority of "down days" would occur in May (2 or 3 days), September (2 days), and October (3 days), while one day down would be all that one might expect in June, July, and August. Assuming the vessel is new and time out for breakdowns is minimal, this report discounts 144 total annual fishing days by 11 for adverse weather. This makes 133 days as the total number of annual fishing days when delivering to a floating processor.

For vessels delivering fish to a shore-based plant, the limiting factor is not the capacity of the vessel, but the limited amount of time the fisherman has before the product becomes unmarketable. The main limiting factor for the vessel heading and gutting Pacific whiting, with the present state of the art, is the amount of fish that can physically be headed and gutted in a day.

For mode A, the maximum safe amount of time Pacific whiting is able to keep in chilled seawater is 2 days. In addition, at this time, Pacific whiting cannot be fished at night with any success because they feed in a dispersed fashion near the surface. These limitations allow a maximum number of 2 days fishing for mode A, with a minimum of 1 day at port to unload, refuel, restock supplies, and rotate the crew. Extrapolated throughout a month, this represents a total of about 20 days fishing per month, or 120 days fishing per season, not including time out for weather and other complications.

Twenty days have been assigned modes A and B as the number of days held in port due to adverse weather. This represents more down time than mode C because of the greater susceptibility to extreme seas over river bars, and complications that might occur from bringing the product in when a shore plant is closed. This leaves mode A with a maximum of 100 fishing days a season.

When considering the fishing schedule for mode B, however, a slightly longer amount of fishing days are allotted due to the fact that Pacific whiting will keep longer in ice as a headed and gutted product than round product will in chilled seawater. With headed and gutted Pacific whiting upholding its quality for 3 days, a fishing vessel in mode B could optimistically fish for 3 days, run in, unload for a day, and return for another 3 days of fishing. This schedule is reduced to a less demanding, more practical framework by alternating 3 day fishing periods with 1, then 2 day increments of down time. Extrapolated consistently throughout the season, the mode B fishing schedule shows an average of 20.5 days of fishing per month, or a total of 123 fishing days a season. Subtracting 20 days calculated for presumed down time, mode B is left with 103 total fishing days per season.

It must be remembered, that with the present understanding of Pacific whiting product shelf life, there is a good possibility of delivering fish that is below food-quality standards. Modes A and B might expect 10-40 percent weigh-back (bad product rejection) due to a myriad of reasons. Mode C has less chance of delivering a substandard product because the close proximity of the trawler and processor implies less chance of fish spoilage.

Daily Catch Rate (5)

Schools of Pacific whiting arrive off the coast of Oregon in enough numbers that warrant fishing to begin off Coos Bay around the first of May. Catch rates increase throughout this month and remain at a high level from June through September as populations of Pacific whiting continue their feeding migrations northward into Washington. In October, catch rates taper off.

Even though this paper analyzes three separate methods of delivering freshly caught Pacific whiting, it can be assumed that a given vessel will be able to catch as much fish with a given amount of effort as a similar vessel with a different mode of delivering fish.

The *Lady of Good Voyage*, toward the end of the 1978 whiting season, was able to pull in tows of up to 17 t in 8 minutes. Barry Fisher expects to land from 1,000 to 1,200 t of whiting in the months of June through September. In May and October, the catches would be a little less at 700 and 800 t, respectively. Therefore, 42 t a day could be achieved as an average amount caught throughout the season.

This catch rate is representative when compared with an estimated catch rate worked up by Hillstrom Shipbuilding Co. of Seattle (Andrews[4]). Based

[4]Andrews, R. 1978. Economic appraisal of catcher/processor to produce Pacific whiting fillets. Unpubl. manuscr., 17 p. Hillstrom Shipbuilding Co., Bellevue, Wash.

on the 1976 vessel observer program, three Polish trawlers had a total catch of 11,400 t. There were 995 tows of approximately 2 hours each producing an average catch per tow of 11.45 t, thereby, a daily catch rate of 51.525 t with an average number of tows per day at 4.5. This large fish catch can be discounted when taking into consideration the Polish vessel size and the subsequent depth of tows.

Since Pacific whiting has such delicate flesh, the emphasis with this fishery is not to catch overwhelming amounts of fish per tow, but to catch a maximum amount in a tow and still maintain a quality product. Wally Welch, skipper of the *Willapa Bay*, has been fishing Pacific whiting for many years off Astoria, Oreg. Welch has said that 15,000 pounds in one tow is the maximum amount desirable to maintain quality standards set up by markets in the United States. Welch presently processes Pacific whiting into fillets on shipboard for delivery to shore facilities.

However, Walter Pereyra, Vice President of Marine Resources Inc., stated that to maintain standards of quality and to achieve a Soviet processing throughput of 60-70 tons a day, fishermen fishing for Marine Resources Co. would most likely be limited to 12 tons a tow. To help achieve this, new designs are being instituted for the 1979 season. "Windows" are being implemented into the upper level of the cod-end so that when a desirable amount of catch is achieved, the remaining portion will be able to spill out. Pereyra also indicated that since the product processed aboard Russian BMRT's belongs to Marine Resources Co. and competes with frozen whiting blocks on the world market, quality standards can be expected to be stringent enough so that if any portion of the delivered product is fit only for fish meal, the fishermen can expect a lower price to be paid as a result.

Forty-two tons a day is the amount of fish caught that was achieved by a very efficient trawler making in the range of 2-6 tows per day. Catch per unit effort in this fishery is likely to be sustained in the foreseeable future as foreign fishing effort is gradually replaced by domestic fishing effort.

Given the present state of the art, a vessel delivering headed and gutted fish will not be able to catch 42 tons a day because the majority of it would spoil due to the amount of fish the heading and gutting machine can process in a day.

The Baader 160 is a West German heading and gutting machine. The amount of fish headed and gutted depends on the operator's skill and ocean conditions. Experienced Soviet seamen are reported to head and gut 45 fish/minute in calm seas, but a workable figure can be pegged at 35 fish/minute, given crew's breaks, sea conditions, machine problems, and degrees in crew efficiency. Heading and gutting 35 fish/minute yields 2,100 fish/hour, and since the average whiting weights 2.2 pounds (Nelson and Larkins, 1970), the total weight of raw product processed per hour is estimated at 2.31 tons. Assuming a heading and gutting machine might begin operating at 8 a.m. and finish processing at 11 p.m., operating continuously by a rotated crew, the total number of hours operated per day will probably be around 15. Heading and gutting for 15 hours will allow a gross weight of 34.65 tons to be processed per day. Since the yield on a headed and gutted Pacific whiting is roughly 60 percent, 20.79 tons of headed and gutted Pacific whiting is the estimated weight delivered per day for mode B.

Annual Catch Rate (6)

The calculation of annual catch rate is derived by multiplying the daily catch by the number of days fished per season.

Ex-Vessel Price (7)

For round Pacific whiting, Marine Resources Co. offered $0.06 a pound when processed aboard Soviet BMRT's in September and October of 1978.

Gross Stock (8)

This calculation is derived from multiplying annual catch by the ex-vessel price.

Fuel (9)

As previously stated and for purposes of this paper, the Pacific whiting fishing grounds are said to be at the most, a 6-hour run from Coos Bay. Cruising at a speed of 10 knots, the vessel's two highly efficient turbocharged diesels yield the vessel a fuel consumption rating of 30 gallons/hour. In addition to running between the grounds and port, cruising is also performed while searching for fish which has been reported to take place in this fishery about 3 to 4 hours/day. Fuel consumption is said to be the same for cruising as it is for trawling with this vessel, which takes place anywhere from 2 to 7 hours/day. Barry Fisher reports that an overall daily average of 300 gallons/day was achieved by the *Lady of Good Voyage* over a 5.5 week period. This includes fuel used for the auxiliary engine.

Rates of fuel consumption were based on 30 gallons/hour as an overall rate of consumption for trawling and prospecting. Each mode was broken down into respective hours running and fishing in conjunction with associated fishing schedules, minus fuel saved during calculated down time.

Price for diesel fuel, when bought in quantities over 1,000 gallons at Ballard Oil of Seattle, was 41.6 cents/gallon. Due to price fluctuations along the coast of Oregon and the probability of fishing time over and above the scope of these figures, 45 cents/gallon was the price used in computing fuel consumption.

Mode C fishes a total of 192 hours/month and runs between port and the fishing grounds 36 hours/month. Consuming 30 gallons/hour, this vessel consumes 5,760 gallons of fuel while fishing per month. This implies the vessel will consume a total of 6,840 gallons/month, or 41,040 gallons/season. Allowing for a savings of 2,520 gallons during the presumed down time of 11 days, at 45 cents/gallon, the total seasonal fuel expenditure for mode C is $17,334.

Mode B fishes a total of 164 hours/month and runs between port and the fishing grounds 84 hours/month. Consuming the same 30 gallons/hour, this

vessel consumes 4,920 gallons of fuel fishing per month and 2,520 gallons running per month. The total fuel consumption of this vessel per month is 7,440 gallons, or 44,640 gallons/season. Allowing for a savings of 2,400 gallons during the presumed down time of 20 days, at 45 cents/gallon, the total seasonal fuel expenditure for mode B is $19,008.

Mode A runs between the fishing grounds and port a total of 126 hours/month and fishes 140 hours for a total of 266 operating hours per month. Consuming 30 gallons/hour, mode A's vessel consumes 42,180 gallons/season, excluding 5,700 gallons presumably saved during unscheduled down time. At 45 cents/gallon, this vessel's total fuel expenditure stands at $18,981/season.

Provisions (10)

A report to Members of the Nomenclature Committee on Pacific Whiting by New England Fish Company listed the cost of groceries per trawler crew member at $11.00 per day when computing an economic impact for the fisheries complete utilization. This price is representative of 1978 food prices and assumes that no food is eaten on board while the vessel is in port.

Ice (11)

The 1978 price for flake ice when bought from Pacific Hake Fisheries in Astoria, Oreg., was $20.00 a ton.

The amount of ice used per season varies tremendously between the three different modes. Obviously, no ice is used by mode C.

A chilled seawater system (CSW) is utilized by mode A. The method of chilling the product with CSW is much faster and less complicated to operate than a refrigerated seawater system.

Calculating the amount of ice needed by this mode involves adding the total amount of heat required to be removed from the product as well as the seawater medium in which it is held. Once this is determined, the amount of ice needed to meet this requirement is calculated as follows:

1) Assume:
   a) Fish holds are filled completely with fish, seawater, ice mixture;
   b) The amount of energy needed to lower 1 pound of fish 1°F = 0.85BTU (British Thermal Units);
   c) The amount of energy needed to lower 1 pound of water 1°F = 0.94BTU;
   d) 168,000 pounds of fish landed in 2 days plus 112,000 pounds of seawater used in hold equals
   e) 280,000 pounds of seawater and fish equal to the total weight capacity of the vessel;
   f) Fish cooled a total of 25°F, from 55°F to 30°F;
   g) Seawater cooled a total of 20°F, from 50°F to 30°F;
   h) Ice yields 144BTU per pound; and
   i) 20 percent heat lost through hold wall and by other miscellaneous losses.

2) Then, ice required to cool finished load of saltwater and fish mixture:
   a) Fish load = 168,000 lb × 0.85BTU/°F × 25°F = 3,570,000BTU;
   b) Water load = 112,000 lb × 0.94BTU/°F × 20°F = 2,105,600BTU;
   c) Total load = 5,675,600BTU;
   d) Plus 20 percent wall and miscellaneous losses: 1,135,120 BTU;
   e) Total amount of energy needed to freeze product: 6,810,720BTU;
   f) Pounds of ice needed to furnish energy per trip: 6,819,720BTU ÷ 144 lb/BTU = 47,296.66 pounds or 23.65 tons.

Mode A will perform an estimated 50 trips per season. At $20.00 a ton, this requires a seasonal ice cost of $23,650 for this mode.

Due to the difficulty in estimating heat loss on a vessel delivering headed and gutted product, the ice needed by this vessel is determined assuming ice will be loaded at 20 percent of the total estimated product weight. After 3 days of fishing, it is assumed that this vessel can head and gut 103.95 tons of whiting, yielding 62.37 tons of finished product at a 60 percent yield. The amount of ice needed to keep this product sufficiently cold is 12.47 tons. A trawler delivering headed and gutted whiting will perform an estimated 38 trips per season, requiring 473.86 tons of ice per season. At $20.00 a ton, $9,477.20 will be needed for ice by this fishing mode per season.

Lubrication, etc. (12)

Cost of lubricating a vessel can be considered the same for each mode because where one mode uses lubricants more in transportation, such as mode A, another mode makes up for the deficit in increased fishing time, such as mode C.

This figure also denotes items like hoses, spare tools and parts, sanitation chemicals, and other items needed to maintain a safe and efficient operating condition on board.

Contingency (13)

A 5 percent contingency figure is used here due to the unpredictability of circumstances, especially in the fisheries industry. The two contingency figures are incorporated in the operating expense section and in the section listing fixed costs.

Oregon State Landing Tax (14) (0.0025¢ per pound)

At this time, floating processors operating in Federal waters are not subject to State taxes. However, duties paid on finished products brought into the United States affect the processor in such a way as to probably lower the price for raw materials in the future. At this time, however, there is no way to represent this.

Gross Profit For Division (15, 16, 17)

This figure highlights and distinguishes the actual amount of profits per unit effort of the different fishing modes.

There are countless methods used to divide gross profit. The method used in this report is basic and does not go into

the details that make each fishing vessel different from the next.

The gross profit was divided in such a way as to have the crew receive 35 percent, the captain 15 percent, and the vessel 50 percent. To arrive at a crew share figure, the crew percentage was divided by the number of crewmen working for the vessel.

Gross Vessel Share (18)

The total sum left to the vessel for fixed annual costs.

Gear Maintenance (19)

The net presently used on the *Lady of Good Voyage* is a Polish rope wing trawl at an estimated cost of $15,000. This cost is used as a conservative estimate of annual gear maintenance.

Hull Insurance (20)

This figure represents 1.75 percent of vessel value. This is a rather low estimate due to the fact that this is a new vessel. The figure covers the vessel for 6 months of mid-water trawling for whiting and another 2 months of bottom fishing.

Protection and Indemnity (21)

The cost represents a figure of $2,500 per operating crewman, with a limit of $1 million.

Depreciation (22)

The method of depreciation used here is the declining balance method. The reason this method is used is to write off the vessel using a more expedient method in order to afford a more favorable tax posture. One should note here that depreciation values in the early years of ownership are considerably higher than other methods of depreciating equipment. Depreciation figures are not to be deducted from cash flow estimates.

The machinery and electronics are written off in 8 years and represent 40 percent of the vessel, while the hull and other structures are written off in 15 years and represent 60 percent of the vessel. Salvage value on the machinery and electronics is $36,040.65 and is $63,486.31 on the hull.

Business and Indebtedness (23)

This figure assumes a loan of $750,000 at 10 percent per annum.

Income Taxes (24)

Taxes used in this report are in line with the corporate income tax structure: 1) 20 percent on first $25,000 of taxable income. 2) 22 percent on taxable income in excess of $25,000. 3) A surcharge of 26 percent on taxable income in excess of $50,000.

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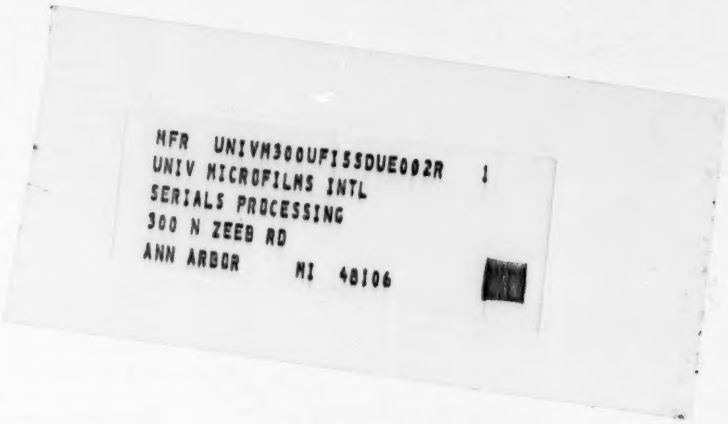
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